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SOME COMMON INDIAN BIRDS.

No. 25. THE GREEN BARBET (*THEREICERYX ZEYLANICUS*).

BY

T. BAINBRIGGE FLETCHER, R.N., F.L.S., F.E.S., F.Z.S.,
Imperial Entomologist;

AND

C. M. INGLIS, M.B.O.U., F.E.S., F.Z.S.

Although common enough where it occurs, the Green Barbet is not found in the less wooded areas of the country, such as the Punjab and Sind, Rajputana and the more open parts of the Deccan and Carnatic. In areas where it does occur, however, it is sufficiently a common bird to merit inclusion in our list, especially as its call is probably more familiar than its personal appearance. It is a thick-set bird, about as large as a mynah, with a thick, heavy bill, in colour of a bright leaf-green with a brownish head and a bare brown patch around the eye; but, as it always keeps near the tree-tops, it is less often seen than heard. Sometimes it may be seen on the wing, when its flight is strong but rather heavy and undulating. Its call is loud and monotonous, but by no means harsh or discordant, and is usually written *tur-r-r-r, kutur, kutur, kutur*, the call being indicated in the various vernacular names, such as *Kotur* (Hindustani), *Kuturga* (Mahratti), *Kotoruwa* (Sinhalese) and *Kutur* (Tamil). The call often sounds much like the word *Pakrao*, repeated several times.

Like most other birds, however, this Barbet is not confined to the use of a single note. In this connection Stuart Baker, in his

"Birds of North Cachar," writing about a very similar and closely allied bird, the Assam Lineated Barbet (*Thereiceryx lineatus hodgsoni*) makes the following interesting remarks: "I have heard this bird libelled as being a bird of one note; now any one who has listened to it *carefully* must admit that it has many. Whilst feeding, it has a large variety of sounds at its disposal. When pleased, it utters a sort of hoarse 'chortle'; but, to make this sound, it seems to be necessary to be on the move, for it always utters it when hopping from one branch to another, or else it gives a little jerk into the air at the same time that it opens its mouth to give vent to its feelings. Displeasure, which seems to be caused chiefly by seeing other birds feeding with it, is expressed by a ridiculously feeble little sound like 'pènch, pènch,' the feebleness being made up for, to some extent, by the bird's ferocious attitude as he advances, with drooping wings and mouth wide open, towards the object of his displeasure. The most unusual note is one it makes use of only in the cold weather, at which time these birds sometimes collect in small flocks, and only in the mornings and evenings, seemingly for the purpose of collecting any scattered individuals. It consists of a loud clear whistle, a most wild and penetrating sound, but at the same time rather musical than otherwise. It is an abnormal sort of a sound for a barbet to give utterence to and had I not followed up and shot some of these birds whilst actually whistling thus, I should never have imagined what had made the sound." The Green Barbet may sometimes be heard calling at night, especially on moonlit nights.

Like other Indian Barbets, this bird lives chiefly on fruit. The late Mr. C. W. Mason examined the stomachs of fifteen birds at Pusa and found nothing but wild fig fruits in them. It is very fond of *Lantana* berries and helps to distribute the seeds of this noxious weed. This bird, however, has a curious habit of pulling off bits of bark from trees, especially from dead branches, as if searching for insects, and Blanford states that it is said occasionally, though rarely, to eat insects. Insects, however, evidently form a very small part of its diet and from an economic point of view this bird cannot be claimed as useful.

Blanford states that the characteristic "call is heard from January or February till June," and Dewar also says that this is heard "during the latter part of the cold weather and the early part of the hot weather." Where the bird is common, however, the call may be heard throughout the year, although more persistently during the first half of the year. As I write these lines (8th November) a Green Barbet is calling at intervals in a nearby tree.

Nesting takes place in a hole in a soft-wooded tree, usually in a dead branch or main stem, excavated by the bird itself, for which purpose its heavy bill seems well adapted.

The nest-hole is rather small, about five inches in diameter, and the passage leading into it is about six inches to two feet long, about two and a half inches in diameter, and very smoothly rounded off inside and bevelled off at the entrance, which is often situated on the underside of a branch and which in any case is always so placed that it does not face upwards, thus avoiding flooding of the nest-hole by rain. The nest is usually placed fairly high up in a tree, twenty feet or more above the ground, but may occasionally be found lower down. No regular nest is constructed, the eggs being placed on a few chips of wood in the nest-hole.

In Bihar the nesting season is chiefly in March and April, but further North eggs may be found in May or even in June. The eggs, which are dull white, and slightly glossy, measure about 30 by 22 mm., and three or four eggs are usually laid.

The Green Barbet is now divided into three subspecies, the typical form (*T. zeylanicus zeylanicus*) being found in Ceylon and South Travancore, the form found along the West coast of India from North Travancore to Bombay being *T. z. inornatus*, and that found in Northern India, from the extreme West to Western Bengal, being *T. z. caniceps*. It is this last subspecies which is represented in our Plate.

THE UTILIZATION OF INDIGENOUS PHOSPHATES IN INDIA.

BY

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Imperial Agricultural Bacteriologist.

Next in importance to nitrogen, as a soil constituent requiring renewal, comes phosphorus, the supply of which in farmed lands has been a source of anxiety to the cultivator ever since it was discovered to be a necessity for the growing crop. Nitrogen can be transferred to the soil from the inexhaustible supply in the air by green manuring and the use of leguminous crops, but no such natural means of renewing the soil supply of phosphorus exists and for this reason the question of its presence in adequate quantity is an acute one for the farmer. Although phosphatic manures were used in very early times it was not until de Saussure discovered their fertilizing action to depend upon their content of phosphorus that any attention was paid to the question of the actual utilization of this constituent, and particularly to the reasons underlying the comparatively slow action of such phosphatic manures as were then available.

Bones were used very early as fertilizers but the slowness of their action was always recognized. The first step taken to reduce this disability was the use of grinding machinery by Anderson of Dundee in 1829; there is also evidence of the early use of fermentation with organic matter in the form of composts. That the fertilizing action of such manures was due to phosphorus was not known until the time of de Saussure, and was emphasized by Liebig when stating his law of the minimum. It was Liebig in 1840 who suggested the use of sulphuric acid as a means of hastening the fertilizing action of bones and this was taken up by Lawes and extended to include mineral phosphates, especially coprolites. This was the

origin of the superphosphate industry which now supplies available phosphates to crops all over the world.

Consideration of the economic aspects of the use of sulphuric acid for solubilizing phosphates led to recognition of the fact that as superphosphate only contains about half the quantity of phosphoric acid which is present in the rock phosphate from which it is made, this available phosphate is not only more costly than the original inert form, but transportation charges are correspondingly greater. Consequently much experimental work has been carried out to discover the possibility of making successful use of the original rock phosphate brought as nearly as possible into an available condition by fine grinding. It is now fairly well known under what conditions such finely ground but chemically untreated phosphates may be used with success, and it may be of interest to state here the conclusions arrived at in general terms.

(1) The value of ground phosphate is strictly determined by the fineness of the grinding.

(2) No good results can be expected in soils deficient in organic matter, but in those containing a high percentage of humus, finely ground rock phosphate may give as good results as equivalent amounts of superphosphate.

(3) In highly calcareous soils unless the supply of organic matter is maintained at a high level, no good results can be expected with rock phosphate. It may be mentioned here that, so far as the highly calcareous soils of North Bihar are concerned, this restriction also applies to superphosphate as has been shown by many experiments at Pusa.

A recent method of attacking this problem consists in carrying the mechanical subdivision of the mineral phosphate to a much further degree of fineness by special grinding machinery, resulting in reduction of the particles to the colloidal state. The relative economic efficiencies of this method and of the chemical one will evidently depend very largely upon the cost of the mechanical disintegration, but it is probable that this latter method may have a

special value for low grade phosphatic minerals whose content of iron or other impurities renders them unsuitable for the production of superphosphate.

Many experiments have been made with a view to increasing the availability of rock phosphates by what may perhaps be styled natural means, such as by contact with fermenting organic matter. In such empirical experiments many substances have been made use of, including peat and farmyard manure; laboratory work introducing examination of the action of bacteria in such mixtures has been carried out by numerous investigators; although positive results showing solvent action were sometimes recorded the general conclusions arrived at were unfavourable to the supposition that the fertilizing action or, at any rate, the solubility of rock phosphates could be increased to any serious extent by this method. On the other hand it is possible to show, as has been done in the writer's laboratory at Pusa, increased fertilizing effects on growing crops, apparently due to partial solubilization of mineral phosphates by the fermentative action of bacteria, in composts with such organic materials as oilcake and green manures.

A great step in advance was made when the oxidation of sulphur and formation of sulphuric acid by certain classes of soil bacteria was shown by Lipman in 1915 to be of practical importance as applied to the problem of solubilization of mineral phosphates. It is interesting to note that the same idea was made the subject of a patent by Panknin in 1877 and later by Chisholm in 1904, but the failure of either of these to secure practical recognition was evidently due to their ignorance of the biological factor involved and consequently of the essential conditions necessary for success. Lipman, McLean, Waksman, and others have placed this matter on a sound practical basis, and work at Pusa during the past three years has demonstrated the possibility of making use of the method in India. It has been shown at Pusa that the addition of sulphur to a compost containing indigenous mineral phosphates results in partial solubilization of the latter as a result of the oxidation of the sulphur by soil bacteria, and that such composts exercise a fertilizing action on growing crops. It has been further

shown that such solubilization of phosphates is greatly increased by the use of cultures of sulphur oxidizing bacteria, isolated in the first place from such composts, as much as 88 per cent. of the insoluble mineral phosphate being rendered available in ten weeks. The results of a typical experiment are given in Tables I and II. Further experiments are in progress to determine the optimum conditions required for this process, and the relative quantities of sulphur and rock phosphate involved. With regard to this last point it must be remembered that there is a definite quantitative ratio between the amount of rock phosphate to be solubilized and that of the sulphur required for this purpose, the actions involved being purely chemical although resulting from biological metabolism; the particular reaction resulting in solubilization of tricalcic phosphate commences with the formation of sulphuric acid and the amount of this, and consequently of its constituent sulphur, required for completion of the desired change may be calculated from the formula :—

$$Ca_3\,(PO_4)_2 + 2\,H_2SO_4 = CaH_4\,(PO_4)_2 + 2\,CaSO_4.$$

Then 310 parts by weight of tricalcic phosphate require 64 parts of sulphur for complete reaction, giving a ratio of one part of sulphur to five parts of rock phosphate. In actual practice various considerations modify this ratio, the principal one being the limitation of the oxidation of the sulphur to some 70–75 per cent. of the amount present in the period of time, some ten to fifteen weeks, conveniently occupied by the process. The diversion of some proportion of the oxidized sulphur into combination with other substances present, either as impurities in the rock phosphate or in the soil used for dilution of the compost, must also be taken into account. On the other hand the nature of the rock phosphate and its probable content of other minerals than tricalcic phosphate themselves unacted upon by the oxidized sulphur, will reduce the amount of sulphur required. McLean in America has found a ratio of 120 parts of sulphur to 400 parts phosphate satisfactory in presence of 2,000 parts of soil, and this sulphur-phosphate ratio has also been found satisfactory at Pusa. With reference to the proportion of soil and the necessity of using this latter as an ingredient of such composts, there is at

present considerable difference of opinion and experience; it is obvious that the handling of large quantities of soil will necessarily increase the cost of this method, but there are hopeful indications that the proportion of this ingredient may be considerably reduced and in fact that it may possibly be eliminated altogether.

This question is under experiment at Pusa at present, but it is clear that the character of the soil itself must play an important part in deciding it; in many instances this factor will carry very considerable weight, as for example in the case of most of the tea soils of Assam whose deficiency in lime will offer specially favourable conditions for the solubilization of the rock phosphate; this process will further be facilitated in these soils, where aeration, an essential condition for success, is readily secured and already arranged for in the routine of garden cultivation.

In whatever manner soluble phosphate is produced from mineral or other insoluble phosphates, on introduction of the resulting soluble product into the soil, reversion to the insoluble form will take place at a rate varying with the amounts of various substances, such as lime, present in the soil itself. As the plant can only take up its requisite supply of phosphatic and other nutriment at a pace which is limited by its rate of growth and assimilative capacity, the ultimate fate of the soluble phosphate applied as manure to the soil will depend upon two opposing factors, the rate of assimilation by the plant and the rate of reversion in the soil. To these two may be added a third, namely, the absorption of phosphate by micro-organisms in the soil, which, although it is probably of considerable importance, may be left out of consideration for the present as not affecting the question at issue to the same extent as chemical reversion. Now the use of a properly constituted compost containing mineral phosphates with the due proportion of sulphur, and inoculated with the appropriate sulphur oxidizing bacteria, would tend to overcome this difficulty by providing a continuous, although small, supply of soluble phosphate, as the oxidizing action would continue in the soil receiving the mixture provided adequate aeration and moisture were secured. Although it would, of course, be impracticable to make any accurate measurements which would

allow of exact adjustment of the two rates of solubilization and assimilation, nevertheless it is obvious that such a method of making use of the natural sulphur oxidizing power of soil organisms would be preferable to that of merely obtaining soluble phosphates by this means, and applying the product, as superphosphate is applied, in one dose with the inevitable result of loss by reversion. Here we have a parallel to the case of nitrogen supplied as nitrate of soda, much of which is lost to the crop in Indian soils partly as a result of leaching by rain and partly by reduction and assimilation by bacteria. The manurial value of oilcake as a source of nitrogen is well known to be high in this country and the writer demonstrated many years ago the notable advantages of the divided dose in applying cake in the cultivation of tea, this advantage being undoubtedly due to the continuous supply of nitrate secured to the growing crop by the nitrification of the cake, and the extension of the period of this supply and the avoidance of loss by use of the method of the divided dose.

In place, therefore, of making use of a fully matured compost, i.e., one in which oxidation of the sulphur and with it solubilization of a corresponding proportion of the mineral phosphate had been carried to a conclusion, such a compost might with advantage be applied to the soil requiring phosphate manuring at an earlier stage of maturity, so as to secure the continued and gradual supply of soluble and available phosphate the advantages of which have been indicated above. Selection of the particular stage of maturity most suitable for use with varying crops and soils would be a matter for experience and experiment to determine, but there can be no doubt that this method would in many cases present advantages over direct application of fully matured composts, just as the bringing into use of indigenous supplies of phosphates in this country by making use of natural fermentative processes must constitute an advantage over the importation of superphosphate from abroad or even over that of manufacture by chemical processes in India.

As will be seen from the results given in Tables I and II the use of cultures of sulphur oxidizing bacteria is necessary to obtain any high degree of solubilization. On the other hand it is not essential

to use pure cultures, nor has this been done by most workers on this subject, partly because of the difficulty of obtaining them in an active condition, but largely because of the effectiveness of inocula merely drawn from composts in which sulphur oxidation has been firmly established by suitable treatment. This method is very similar to that made use of in connection with nitrification both of sewage and in saltpetre production, and there are further resemblances between these two natural oxidation processes which will be referred to again later in this paper. As a practical method, therefore, there is nothing to prevent its adoption by properly instructed, although otherwise entirely unscientifically trained individuals, and although in the initial stages of its adoption and use it might be advisable to make use of a certain measure of scientific control, involving perhaps the preparation of the composts at centres of distribution, later on there should be nothing to prevent the cultivator from preparing his own composts, making use of inocula originally provided, preferably by officers of the Agricultural Department, but subsequently carried over from one preparation to the next in a manner familiar to the makers of both country spirit or rice beer, and of curdled milk (*dahi*).

It is interesting to note that the addition of sulphur to soils produces fertilizing effects which may be attributed to actions other than that of solubilization of phosphate. So far, although many guesses have been made to account for this result, we have no accurate knowledge sufficient to account for it. The increased fertility has been attributed to partial sterilization, to the production of an acid reaction and consequent neutralization of excessive alkalinity, and to interference with the growth of injurious fungi, parasites and weeds. These latter claims have been made for a recent French patent which, however, makes no reference, at least in the published account of it, to the solubilization of phosphates, and appears to be no great advance upon the earlier patents of 1877 and 1904 except in regard to the recognition of the biological factor. Experiments in the writer's laboratory in 1912 showed very varying effects of the addition of sulphur upon the bacterial content and activities in different soils. A selective action was evident,

resulting in multiplication of certain species with diminution of others, but this was evidently attributable to the modified reaction of the soil due to formation of acid, nor was it possible with the data obtained to draw any valid conclusions as to the causes of increased fertility from the observed effect of added sulphur upon the bacterial processes usually associated with this condition. The striking results of the addition of sulphur to the soil of Assam tea gardens in the relatively small quantities provided by the operation of sulphuring the bushes against "red spider" attacks, was pointed out to the writer in 1904, and it was further evident that the increased growth of leaf in many cases resulting from this operation could hardly be due to the reduced activity of the insect attack, as it appeared in situations practically free from the latter. In view of the importance of the action of sulphur bacteria as potential providers of available phosphate from otherwise insoluble minerals, and the possible introduction of the use of the "immature" composts described above with their content of unoxidized sulphur, it would probably be worth while carrying investigation of the other actions of sulphur in the soil to a further degree than has hitherto been done, and such an enquiry may be recommended for consideration by soil chemists, mycologists, entomologists, and bacteriologists as worthy of attention.

An interesting parallel exists between the activities of sulphur oxidizing and nitrifying bacteria in soils. Both are oxidation processes requiring adequate aeration and a sufficiency of moisture, and both result in the neutralization of the acid formed by combination with a base. In the case of the sulphur bacteria these organisms are able to function in the presence of a high concentration of the acid by-product of their metabolism, whereas the activity of the nitrate formers is strictly limited by any such accumulation and requires the presence of a base, such as lime, to avoid interference with the process. On the other hand both classes of organisms are sensitive to the inhibitory action of excess of organic matter, the presence and character of which requires careful regulation if satisfactory results are to be obtained. Long experience has taught the practical agriculturist, as well as the sewage expert,

in what manner the problem of the nitrification of large quantities of organic matter may be dealt with, and it is probable that, where the combination of the latter with minerals in a compost is likely to be of value, careful experimental work will discover practicable methods of carrying this out without prejudice to the oxidation of sulphur and the resulting solubilization of the tricalcic phosphates present. The above described parallelism between sulphur oxidation and nitrification suggests a highly desirable alternative to the former process as a means of obtaining soluble phosphates from natural mineral sources. In theory there is no reason why the second process should not be substituted for the first as a means for attaining this end, the tricalcic phosphate serving as the base to neutralize the nitrous acid resulting from the nitrification of the organic matter present. Hopkins has shown that soluble phosphate can be got as a result of the normal processes of nitrification in presence of rock phosphate, and although at present the practical application of this method has still to be worked out, the obvious advantage of being able to dispense with the necessity of spending money on sulphur, indicates the advisability of research into the possibilities of this alternative method in a country where climatic conditions are generally favourable to a high rate of nitrification. Considerations of space preclude further discussion of this subject, but it may be said here that work in the writer's laboratory has demonstrated the possibility of greatly increasing the activity of nitrifying organisms and the rate of nitrification, by simple bacteriological methods, which may possibly be applied successfully to the practical elucidation of this interesting problem.

In conclusion it may be pointed out that India possesses deposits of natural rock phosphates, such as those of Trichinopoly and Bihar, and also an unfailing supply of bones, neither of these potential sources of phosphatic plant food being at present utilized to any considerable extent for manurial purposes. One reason for this neglect of such sources of soil fertility is the simple economic one of the cost of the manure and the relations between this amount and the value of the increased crop obtained by such expenditure; this in many cases, if not in most, does not present a balance on the

right side when the cost of imported superphosphate is concerned, nor in the present stage of industrial development of this country is it probable that locally produced superphosphate would improve the position. The cost of production of superphosphate in this country would be largely influenced by the capital cost of the plant for production of acid and treatment of the mineral phosphate therewith, together with the heavy overhead and depreciation charges associated with such enterprises in India. These, rather than the cost of raw materials, would probably determine the economic balance of such an undertaking, whereas, by making use of natural fermentative processes such as that outlined above, these heavy additional expenses are largely eliminated. It is not claimed that by so doing available phosphates can be obtained at a negligible cost ; there will still remain the necessity of providing grinding machinery and of paying for the sulphur and the raw phosphatic materials and their handling and transport. It remains to discover whether the elimination of the manufacturing costs of sulphuric acid and of superphosphate in India will reduce the final cost of available phosphate, made by this natural process from indigenous materials, to such a degree as to allow of the extension of its use beyond the narrow limits which at present confine its application to a small minority of revenue crops. The object of this paper is to suggest such a possibility and also to draw attention to the advisability of investigation of the subject by competent and interested workers in this country.

Table I.

Solubilization of mineral phosphate by sulphur oxidizing bacteria.

	Period	Mg. of P_2O_5 as rock phosphate	Mg. of P_2O_5 found available	Mg. of P_2O_5 solubilized	Per cent. of insoluble P_2O_5 solubilized
Culture No. 1 ..	At start ..	281·6	25·6 *	..	....
	After 2 weeks ..		30·8	5·2	2·03
	After 4 weeks ..		53·2	27·6	10·78
	After 8 weeks ..		152·8	127·2	49·70
	After 10 weeks ..		196·9	171·3	66·90
Culture No. 2 ..	At start ..	281·6	25·6	..	....
	After 2 weeks ..		34·2	8·6	3·36
	After 4 weeks ..		47·9	22·3	8·71
	After 8 weeks ..		178·9	153·3	59·80
	After 10 weeks ..		253·4	227·8	88·90

* Contained in culture medium.

Table II.

Action of sulphur oxidizing bacteria on mineral phosphate and on pure tricalcic phosphate, in 10 weeks' time.

	Mg. of P_2O_5 added	Mg. of P_2O_5 found available after 10 weeks	Increase over control	Per cent. of insoluble P_2O_5 rendered soluble
(1) Action on mineral phosphate				
Control	281·6	25·6 *	..	....
Culture No. I	..	196·9	171·3	66·9
Culture No. II	..	253·4	227·8	88·9
(2) Action on pure tricalcic phosphate				
Control	302·0	56·2	..	....
Culture No. I	..	216·0	159·8	65·0
Culture No. II	..	292·0	235·8	95·9

* Contained in culture medium.

SOME CORRELATIONS IN THE CHARACTERS OF KANKREJ CATTLE IN THE BOMBAY PRESIDENCY.

BY

E. J. BRUEN,

Deputy Director of Agriculture for Animal Breeding, Bombay Presidency.

In the Bombay Presidency, there are large numbers of professional cattle breeders who have been engaged in this work for many generations. Like the old breeders of European countries these are usually illiterate but at the same time very observant of points in their cattle. The vast amount of knowledge thus accumulated for generations has been handed down not in the form of characters which are connected with good qualities, but as superstitions regarding lucky and unlucky markings. For instance, a cow or bull with a " feather " situated in a particular spot is supposed to make it an extremely lucky or unlucky animal to the owner.

As the cattle breeders have such superstitious fancies it is difficult to distribute bulls bred on Government farms, no matter how well-developed they may be, if they do not possess these " lucky " signs or markings. Due to this, numbers of well grown bulls of known and good pedigree are continually being left on these farms to be eventually castrated. It is evident, in fact, that if the cattle of the country are to be improved, it will be necessary for a long time to come that due consideration be given to the opinions and prejudices of the breeders with whom we must work.

The Manager of the Northcote Cattle Farm, Chharodi, Mr. M. M. Desai, has endeavoured to correlate some of these lucky signs with the more regular methods of judging or selecting cattle. Until our breeders become more familiar with the pedigree

system of selecting cows, I believe it is our duty to set out the advantages and disadvantages of a particular type of animal to them in such a manner that they will, to their own way of thinking and judging, accept what we realize to be really good material. It is my conviction that all these lucky or unlucky signs require investigation, and that, if this is made, many of them may be found to be closely correlated with really useful characters in the stock. I therefore give below a few of the signs of the Kankrej cattle of Gujarat which are held in high repute by the " Rabari " or professional Kankrej breeder, and their correlation with our own observations.

It is undoubtedly due to strict adherence to the principle of utilizing as far as possible only cattle possessing such markings that the Kankrej, or for the matter of that any pure breed in India, has been kept up to the standard in which we find it to-day. I may here observe that we find good and pure cattle only in those areas where there is such a person as a professional breeder.

(1) *Length of face.* The professional breeder of Kankrej cattle gives preference to a short face, this being the first part of the external anatomy to be examined in selecting an animal. No matter what other good qualities it may possess, if the face is not short the animal is rejected. No Rabari will accept a bull with a long face to head his herd. The professional breeder, however, cannot offer any explanation as to why he prefers an animal with a short head.

The connection of the length of face of a Kankrej cow with the age at which it matures has been tested in a large number of cows of the Chharodi herd. The time of maturing has been measured by the age at which the first calf was dropped, and the attached correlation table between the two characters shows their relationship. The age at which the first calf was dropped has been classified to within six months, none being dropped under the age of $3\frac{1}{2}$ years.

A study of the figures shows that there is a correlation, though only a slight one, between the characters studied, and thus there is a distinct likelihood for a long faced animal to be late in maturing. Taking unity (1) as representing absolute connection between the

Correlation between length of face and age of dropping first calf.

Length of face in inches	Age of dropping first calf											
	3½ to 4 years	4 to 4½ years	4½ to 5 years	5 to 5½ years	5½ to 6 years	6 to 6½ years	6½ to 7 years	7 to 7½ years	7½ to 8 years	8 to 8½ years	8½ to 9 years	Total
18 ..	..	..	1	3	..	..	1	1	..	..	..	6
18½ ..	1	1	4	2	1	1	..	..	..	..	..	10
19 ..	1	2	4	8	7	6	2	1	1	1	1	34
19½ ..	1	1	..	1	5	3	1	1	1	..	..	14
20 ..	..	1	5	12	2	1	3	2	..	1	..	27
20½ ..	..	..	..	1	3	1	2	..	..	..	..	7
21 ..	..	1	..	..	2	2	..	..	..	..	..	5
22 ..	..	..	..	..	..	1	..	..	..	1	..	2
Total ..	3	6	14	27	20	15	9	5	2	3	1	105

two characters, the coefficient of correlation works out as + 0·183 with a probable error of ± 0·064. This high probable error suggests that the number of observations has not been sufficient to make the correlation a certain one, and it is obvious that the matter needs further study with a larger range of animals. I am putting the figures on record, however, because if such a correlation be established in any breed of Indian cattle the length of face would become a very important indication in breeding in this country.

(2) *Length of ear.* Long pendulous ears are much preferred in Kankrej animals by the breeders of Upper Gujarat and this would appear, by the measurements made on the Chharodi herd, to have a correlation with the length of the body. The tendency would appear to be for a long ear to be associated with a long barrel, and the longer the barrel the better the constitution, the more food space and better digesting power. The following correlation table between these two characters shows their relationship in 95 animals of the Chharodi herd.

Correlation between length of ear and length of body.

Length of ear in inches	Length of body in inches								
	26–26½	27–27½	28–28½	29–29½	30–30½	31–31½	32–32½	33–33½	Total
10–10½ ..	1	4	2	1	..	..	..	..	8
11–11½ ..	..	1	5	3	1	1	..	..	11
12–12½ ..	..	7	9	6	1	2	..	..	25
13–13½ ..	1	3	5	7	2	3	..	2	23
14–14½ ..	..	1	7	3	9	2	1	1	24
15–15½ ..	..	..	..	2	..	1	..	..	3
16–16½ ..	..	..	..	..	1	..	..	..	1
Total ..	2	16	28	22	14	9	1	3	95

The mean length of the ear in the animals examined was 12·8 inches, and the mean length of the body was 30·1 inches. The correlation in this case, while still not very strong, is obviously closer and more certain than in the previous case described. Here, again, taking unity (1) as representing absolute connection between the two characters, the coefficient of correlation works out as $+ 0{\cdot}327$ with a probable error of $\pm\ 0{\cdot}062$. Though the association of long ears and long body is not by any means constant, yet there is certainly sufficient correlation to justify the use of length of ear as one of the factors in the choice of undeveloped animals.

(3) *Dewlap.* The larger and more pendulous the dewlap the better the Rabari likes the animal. This particular development is known as *od.* The cows on the Northcote Cattle Farm, Chharodi, have not been milked in the past. Milking has only been taken in hand within the last three years, and naturally a number of cows on the farm give little or no milk. The dewlaps of some 130 cows have been measured, and, as will be seen by the figures given, there seems to be a greater percentage of animals with large dewlaps in the milking herd than of those with a smaller dewlap.

The natural inference is that length of dewlap is correlated with the milk-yielding capacity—the longer the dewlap the greater the milk.

Correlation between length of dewlap and milk-yielding capacity.

Dewlap in inches	Total number of animals considered	Number of animals found yielding	Number of animals found not yielding	Percentage of yielding animals
$5\frac{1}{2}$ – $6\frac{1}{2}$ ..	20	6	14	30·0
7 – $7\frac{1}{2}$ ..	32	9	23	28·1
8 – $8\frac{1}{2}$ ..	32	9	23	28·1
9 – $9\frac{1}{2}$ ..	20	9	11	45·0
10 –$10\frac{1}{2}$ ..	17	7	10	58·8
11 –$11\frac{1}{2}$ ..	9	6	3	66·6

The figures are by no means conclusive, but they certainly suggest a certain association of the milking capacity with a long dewlap. It is not possible in this case to give a precise measure of this correlation, but it certainly suggests further observations along these lines.

IRRIGATED PADDY: A CONTRIBUTION TO THE STUDY OF FIELD PLOT TECHNIQUE.

BY

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Introduction.

This paper is the result of experiments initiated at Mandalay in 1921 with the object of determining the error of field trials with irrigated paddy and of finding a means to reduce that error. The probable error of small bunded plots at Mandalay had been found to work out to the high figure of 13 per cent., so it was suggested to the writer * that the error of long narrow plots *within* a bunded field should be determined. Errors were calculated by the ordinary and by "Student's" method.[1] "Student's" method largely reduces the error and a modification of this method still more so. As the results obtained may be of interest to other workers this short paper, which is only intended as a small contribution to the study of field technique, has been prepared.

Previous work.

An excellent summary of the work already carried out on the subject of error in field trials is given by Batchelor and Reed[2] (1918). It is curious that no mention is made of "Student's" method which is given as an appendix to Mercer and Hall's paper[3] (1911). Parnell[4] (1919) dealt with the problem in Madras and by

* By Mr. A. McKerral, Officiating Director of Agriculture, Burma, who also suggested the method used in these experiments to demarcate plots.

[1] Mercer, W. B., and Hall, A. D. The experimental error of field trials, with Appendix by "Student." *Jour. Agri. Sci.*, IV, 2, pp. 107–132, 1911.

[2] Batchelor, L. D., and Reed, H. S. Relation of the variability of yields of fruit trees to the accuracy of field trials. *Jour. Agri. Res.*, XII, 5, pp. 245–283, 1918.

[3] Mercer, W. B., and Hall, A. D. *Ibid.*

[4] Parnell, F. R. Experimental error in variety tests with rice. *Agri. Jour. Ind.*, XIV, 5, pp. 747–757, 1919.

using plots 50 feet$\times$4 feet was enabled to reduce the probable error of the difference of *adjacent* plots to 4·2 per cent. ; with plots 50 plants long and 2 plants wide the error of the difference of adjacent plots was found to be the low figure of 3·1 (per cent. ?). This paper also gives the errors of ordinary field plots in India for various crops calculated by the method of Wood and Stratton[1] as corrected by Parnell. Stadler[2] (1921) drew attention to the effects of competition in cereals grown on small test plots and showed a method of preventing this. Where new selections or varieties are under trial at an early stage when seed is scarce the question becomes very important. Beaven[3] (1922) was the first to emphasize the value of " Student's " method in reducing the probable error of experiments, and his paper is of extreme interest and importance in all cases where small differences are being examined. He states that " the well marked reduction of the probable error by ' Student's ' method is largely due to the fact that in this particular field the fertility declines, although not uniformly, from east to west. At another station where divergencies were more irregular in character there might be less difference in the probable errors obtained by the two methods. It appears to the writer, however, to be clear that the second method gives the probable error more correctly and it is more difficult to calculate." Faulkner[4] (1923) has made a quantitative comparison of the accuracy of " Student's " method with the ordinary.

The value of the statistical study of experimental results.

The necessity of a statistical interpretation of the results of field trials is now widely acknowledged but its importance has in many cases been overlooked, e.g., " for the most part the tests of outturns of the different varieties of crops were made on a number

[1] Wood, T. B., and Stratton, F. J. M. The interpretation of experimental results. *Jour. Agri. Sci.*, III, 4, pp. 417–440, 1910.

[2] Stadler, L. J. Experiments in field plot technique for the preliminary determination of comparative yields in the small grains. *Univ. of Missouri Coll. of Agri. Res. Bull.* 49, 1921.

[3] Beaven, E. S. Trials of new varieties of cereals. *Jour. Min. Agri.*, July and August 1922 and Supplement.

[4] Faulkner, O. T. Unavoidable error of field experiments. *Agri. Jour. Ind.*, XVIII, 3, pp. 238–248, 1923.

of duplicate fields quite inadequate to prove (within stated limits of probability) that the differences observed were systematic and not due to genetic or environmental variation."[1]

Attempts are sometimes made to reduce the error of trials by averaging results over a period of years; of this, Fisher[2] (1921) at Rothamsted found that "average wheat yields, even over long periods from different fields or for different seasons, cannot approach in accuracy the comparison of plots of the same field in the same season." It has been noticed that in some cases the yield of a treated plot in one year has been compared with the mean of the control plot over a number of years which means that the effect of the seasonal variation which is exerted with full force on the treated plot is only partially exerted on the control.

Statement of the problem.

Comparatively small differences in yield between two varieties or owing to different treatments are often of sufficient value to cause the new variety to be used or the new treatment to be adopted. But where only small differences are obtained it becomes very difficult to state mathematically that these differences are significant and therefore if the new variety or treatment is really superior. The problem is to reduce the probable error to such an extent that even small differences can be shown to be significant.

Methods.

Long narrow plots within a bunded field were chosen as offering the best chance of successfully tackling the problem. In 1921-22 the plots were 6·6 feet wide by 122 feet long (area 0·0184 acre), and in 1922-23, owing to a re-arrangement of the experiment, the plots were 6·6 feet wide and 174 feet long (area 0·026 acre). In the first year the number of plots was 104 and in the second 72. Plots adjoining bunds were discarded. Four bunded fields were used in both years. The plots were demarcated by a variety of paddy (Mo Hmaw) which, in all stages of its growth, possesses

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[1] Jacob, S. M. *Rept. Punjab Dept. of Agri.*, 1921-22, Pt. I, p. 3.

[2] Fisher, R. A. Studies in crop variation, I. An examination of the yield of dressed grain from Broadbalk. *Jour. Agri. Sci.*, XI, pp. 107–135, 1921.

FIELD PLOTS.

characteristics easily distinguishing it from the pure line Ngasein paddy used in the experiment. The two photographs (Plate I) give a slight idea of this.

The fact that plots are demarcated by lines of paddy only, appears, in the case of paddy, to preclude the adoption of this method for manurial experiments. As well as long narrow plots, single lines of paddy were planted in the hope of discovering a reliable method of testing selections and varieties in cases where only small amounts of seed are available. In plant breeding work, e.g., such a method would enable a breeder to find out and discard useless types at least a year sooner and there would be a large saving in the area of land required. In this experiment only one strain of paddy was grown, so no question of competition arises. This matter requires further investigation but the method used here (lines 3·3 feet apart and plants 18 inches apart in the lines) would seem to preclude the possibility of serious competition. In 1921-22 lines were 122 feet long parallel to the water course. There were 103 lines and the lines adjacent to bunds were discarded. In 1922-23 lines were planted at right angles to the water course and were 174 feet long. Eighty lines were laid down. Owing to the prevalence of crabs at Mandalay this part of the experiment was not successful and it has not been thought worth while to include the results in this paper. In some of the single lines as many as 10 per cent. of the plants were cut down by crabs in a single night and a nursery had to be maintained in order to replace these plants. Further investigation in the light of this experience and in view of the effect of competition described by Stadler (*loc. cit.*) is necessary.

For the ordinary method of computation the following formula was used :—

$$\sigma = \sqrt{\frac{\Sigma d^2}{n}} \qquad \text{and}$$

$$\text{Probable error} = \pm\ 0{\cdot}6745\ \sigma$$

$$\text{Probable error of difference on 2 plots} = \pm\ 0{\cdot}6745\ \sigma \times \sqrt{2}$$

In "Student's" method the differences of adjoining plots were

calculated and the standard variation of these differences worked out. This figure multiplied by ±0·6745=probable error of difference of 2 plots. For purposes of comparison this figure has been worked out as a percentage of the mean yield of all the plots in the particular series.

The third method used in computing errors and the method which has given the best results may be termed "Student's" method modified. Instead of getting differences of adjacent plots, one plot was compared with the mean of the two plots on either side, e.g., if the plots are 1, 2, 3, 4, 5, 6 .... 2 is compared with $\frac{1+3}{2}$; 4 is compared with $\frac{3+5}{2}$ and so on. The differences so obtained are used in the ordinary "Student's" method.

Results.

The yields of the 1921-22 plots are shown in Plate II. Two facts are illustrated by the graphs :—

(1) The yields are highest near the water course and there is a more or less regular decrease across the field.

(2) There is a local increase near the bunds on the far sides of the fields. Yields of plots adjacent to bunds were not used in the calculation of probable errors.

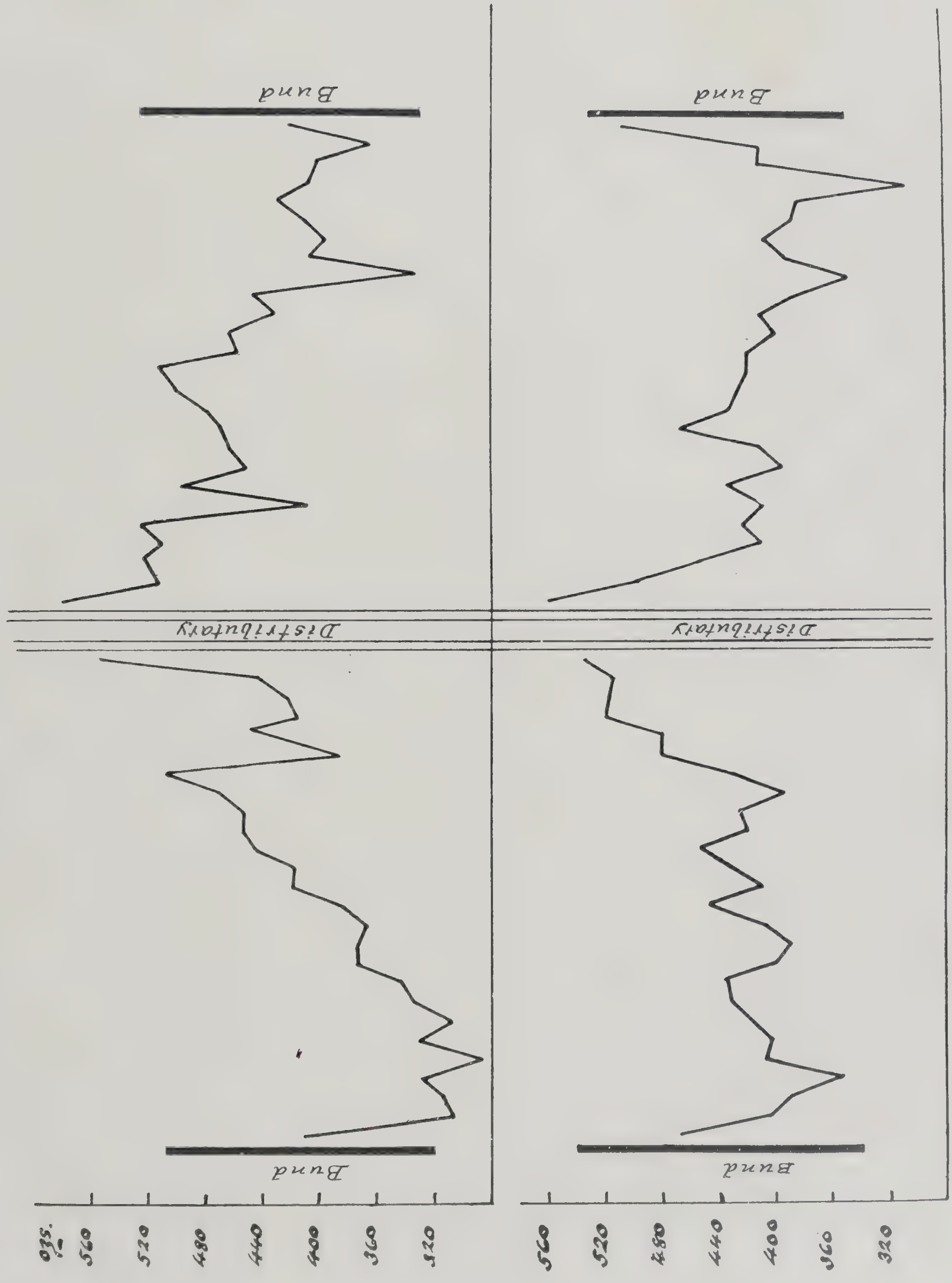
The influence of contiguity to the water channel on yields of plots is probably due to the large amount of silt carried in the irrigation water. Most of this silt is deposited near the water course. The errors are given below :—

1921-22 *plots.*

	Ordinary method	"Student's" method
	Per cent.	Per cent.
Probable error of single plot	± 8·24	....
Probable error of difference of two plots ..	± 11·61	± 5·95

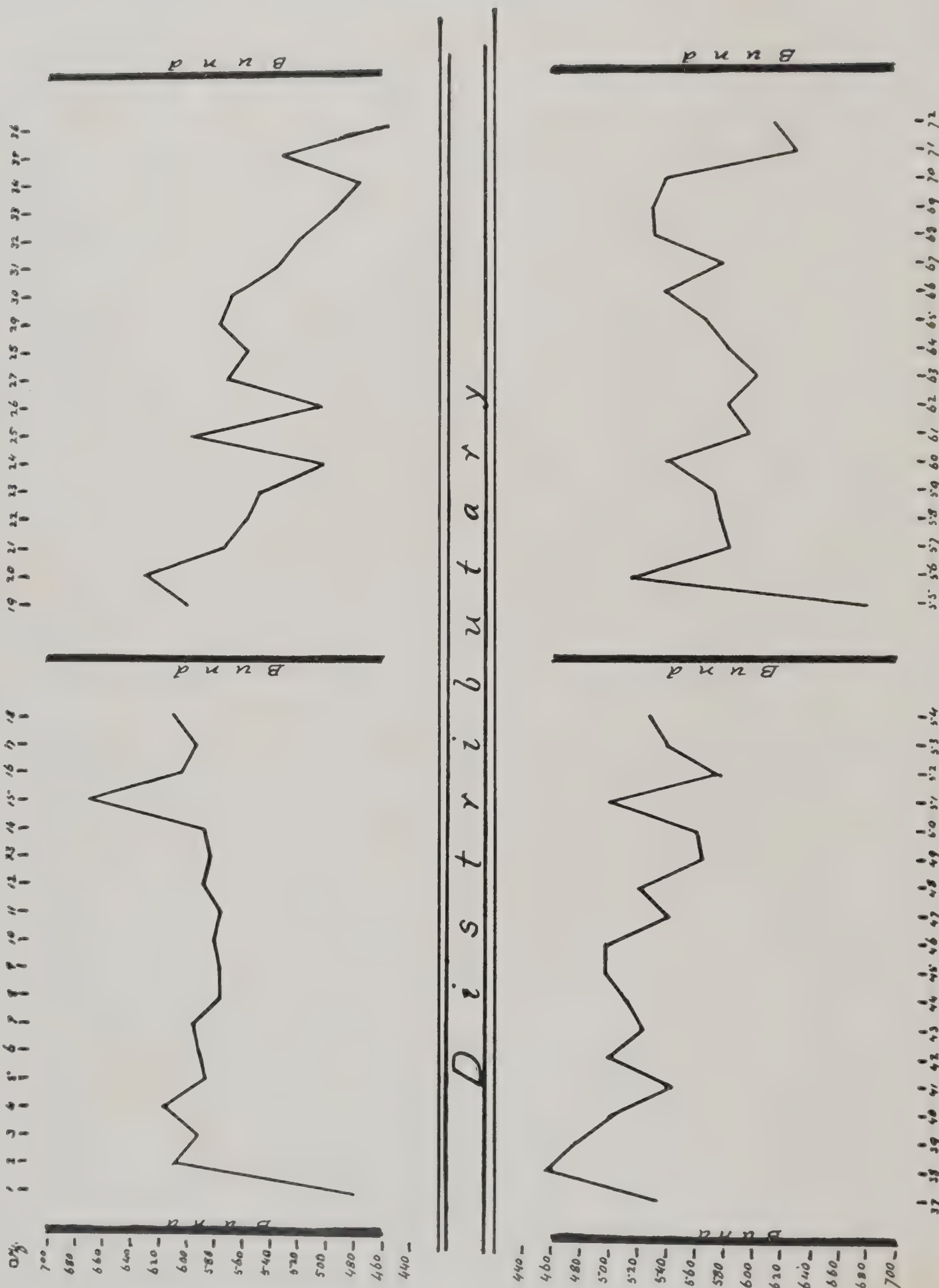
In 1922-23 the plots were laid down at right angles to the water course in order to discount its effect on yields. The results of these plots are shown in Plate III and it will be seen that there

PLATE II.



YIELDS OF LONG NARROW PLOTS, SHOWING EFFECT OF WATER COURSE AND BUNDS.

PLATE III.



YIELDS OF PLOTS AT RIGHT ANGLES TO WATER COURSE.

is no fertility slope in the fields. Plots were planted adjacent to the bunds but were not weighed and included.

1922-23 *plots.**

	Ordinary method	" Student's " method	" Student's " method modified
	Per cent.	Per cent.	Per cent.
Probable error of single plot	± 5·58	....	....
Probable error of difference of two plots ..	± 7·86	± 5·62	± 4·47

The re-arrangement of the plots in this year has made a noticeable difference but in both years the probable error calculated by " Student's " and the modified method is considerably smaller. As is to be expected, the decrease in the error found by " Student's " method is much larger when there is a fertility slope in the field.

The 1922-23 figures were used to compare the errors of the individual fields with the whole series, with the following results :—

Field No.	Ordinary method ; probable error of single plot	" Student's " method ; probable error of difference of 2 plots	" Student's" method modified ; probable error of difference of 2 plots
	Per cent.	Per cent.	Per cent.
1	± 3·86	± 5·07	± 3·62
2	± 5·45	± 4·25	± 4·75
3	± 4·01	± 5·30	± 4·25
4	± 4·62	± 5·45	± 3·49
Average ..	± 4·48	± 5·01	± 4·03
Whole series ..	± 5·58	± 5·62	± 4·47

(It should be noted that the ordinary method only gives the probable error of a single plot.)

The inclusion of four separate fields in the series has had little effect on the results in either method. Four times the probable error of the difference of two plots may be taken as being significant, so even with " Student's " method a certain number of replications are necessary to reduce the error of the difference to a workable

* The writer is indebted to Mr. W. M. Clark, Deputy Director of Agriculture, Burma, for assistance in calculating the 1922-23 resul

figure. Theoretically the probable error of the mean of a number of replications is $\frac{\text{P. E.}}{\sqrt{n}}$ where n equals the number of replications but in practice it is found that systematic replication does not reduce the error according to the theoretical calculation.

Mercer and Hall (*loc. cit.*) recommend the use of five replications ; Roemer[1] states that when the experiment is repeated on more than six plots it does not contribute to any important extent to the accuracy of the "einzelbeobachtung" ; at the Minnesota Experimental Station it was shown that variability decreased rapidly up to three replications, but only slowly thereafter. With "Student's" method the following results were obtained with the 1922-23 yields. Probable error of the difference of 2 plots $= \pm 5{\cdot}62$ per cent.

Replications	Theoretical	Calculated
	Per cent.	Per cent.
2	± 3·98	± 3·14
3	± 3·25	± 3·83
4	± 2·81	± 2·61
5	± 2·51	± 2·53
6	± 2·29	± 2·08
7	± 2·12	± 2·19

The theoretical and calculated errors of replications were also worked out by "Student's" method modified, with the following results. Probable error of 2 plots $= 4{\cdot}47$ per cent.

Replications	Theoretical	Calculated
	Per cent.	Per cent.
2	± 3·33	± 2·93
3	± 2·71	± 2·26
4	± 2·35	± 2·10
5	± 2·10	± 2·50
6	± 1·91	± 1·71
7	± 1·77	± 2·50

Six replications have given the best results in both methods and although absolute accuracy cannot be claimed for the calculated errors, yet there would appear to be good ground for claiming that with six replications the probable error of the difference of two

[1] Roemer, Th. Ueber die Technik der Feldversuche, in *Fuhling's Landw. Zeitung*, Year 67, 5–6, p. 102.

plots can be reduced to 2 per cent. by "Student's" method and below that figure by that method modified.*

In all of the above calculations grain weights of the plots have been used. In cases where it is desired by numerous replications to still further reduce the probable error a large amount of labour is involved in threshing individual plots. It had been found at Mandalay that the correlation coefficient between total weight and grain weight was 0·089 ± 0·02. So the errors of the 1922-23 plots were calculated on total weights with the following results :—

Ordinary method—Probable error of difference of 2		= ± 10·71 per cent.
"Student's" method	ditto	= ± 6·07 ,,
"Student's method modified	ditto	= ± 4·83 ,,

The increase in the probable error over that obtained when grain weights were used is only slight.

Summary.

(1) Under irrigation the yields of plots parallel to the water course tend to increase as the water course is approached.

(2) The probable error of a series is only slightly affected by plots distributed in more than one bunded field.

(3) The probable error of a series is materially reduced by using "Student's" method and by "Student's" method modified it is still more reduced.

(4) Six replications with "Student's" method modified will reduce the probable error of the difference of two plots to below ± 2 per cent. The best method, therefore, of conducting experiments with long narrow plots within a bunded field is as follows :—

C.A.C.A.C.A.C.A.C.A.C.A.C. where C = the control and A = the treated plot.

(5) The probable error obtained by using total weights is only slightly higher than when using grain weights.

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* In working out the calculated errors, owing to the smaller number of averages available, the formula $\sigma = \frac{\sqrt{\Sigma d^2}}{n-1}$ was used.

LINSEED (*LINUM USITATISSIMUM*) HYBRIDS.

BY

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AND

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This crop was first studied in 1916 to elucidate the nature of a number of aberrant plants occurring in the linseeds grown from line cultures on the College Farm, Nagpur, the previous history stating that for 13 years the crop had been uniform. These rogues proved to be hybrids, the result of natural cross pollination. A large number of artificial crosses were raised during the succeeding four years. As the occurrence of natural cross pollination of linseed has not previously been noted in India, and as the figures collected indicate a simpler genotype for the Central Provinces' linseed than that described by Tammes[1] for flax, the facts are now recorded.

Linseed as grown for oil in India is a bushy plant, branching copiously from near the base, occasionally reaching a height of three feet. In the Central Provinces and Berars 5 per cent. of the total cropped area or nearly one million acres, chiefly in the Nagpur, Chhatisgarh and Berar Divisions, are annually sown with linseed either as a pure or mixed crop.

[1] Tammes. Die genotypische Zusammensetzung einiger Varietäten und ihr genetischer Zusammenhang; *Rec. d. trav. bot. néerl.*, XII, 1915. Die gegenseitige Wirkung genotypischer Faktoren; *Rec. d. bot. trav. néerl.*, XIII, 1916. On the mutual effect of genotypic factors; *Proc. Kon. Akad. v. Wet.*, *Amsterdam*, XVIII, 1916. Genetic analysis, schemes of co-operation and multiple allelomorphs of *Linum usitatissimum*; *Jour. Gen.*, XII, 1922. Das genotypische Verhältuis zwischen dem wildem *Linum angustifolium* und dem kulturlein *Linum usitatissimum*; *Genetica*, V, 1923.

Anthesis and pollination in general conform to that described for flax in Holland by Tammes.[1] On a warm morning flowering starts at 7-30 a.m.—half-an-hour after sunrise—while on a cold dull morning it is delayed till 9 a.m., both the actual time of opening and the quantity of flowers being dependent on temperature and humidity. The flowers close by the afternoon and commence to drop only the day after opening, occasionally, however, still adhering even to the fruit.

The cylindrical stigmas which are adpressed together until the corolla has expanded, are receptive on the inner side. By the time the corolla is half expanded the extrose anthers, which in the bud are below but now are level with the stigmas, have dehisced. When the flower is fully open the anthers are forced close to the uncoiling stigmas by the elongation of the claws of the petals, the stigmas actually coming in contact with the pollen covered anthers as described by Loew,[2] and self pollination is effected. The protogynous condition described by Tammes[3] does not occur naturally but is the result of wound and contact stimuli.

Prior to 1915, 14 cases of natural cross pollination occurred on the College Farm. In 1916, 1917 and 1919, only 9 cases were observed in 212 line cultures or less than 5 per cent. when linseed is grown in adjacent lines at Nagpur.

The characters studied in the crosses were first the colour of the corolla and next the colour of the seed-coat.

Blue-flowered × White-flowered.

F_1 had pale-blue flowers with dark blue veins like the blue parent. Twenty-seven plants were raised in F_2, 19 blue and 8 white-flowered; 12 of the blue-flowered again segregating into 937 blue and 319 white-flowered. The ratio obtained from 70 other segregating individuals was 3,205 blue : 1,069 white-flowered. These figures indicate a monohybrid cross.

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[1] Tammes. Die Flachsblüte. *Rec. d. trav. bot. néerl.*, XV, 1918.
[2] Loew, E. *Einführung in die Blüthenbiologie*, 1895.
[3] Tammes. *L. c.*, 1918, p. 220.

Dark brown seed × Yellow seed—flowers white.

F_1 had a dark brown seed-coat. In F_2 segregation occurred giving 15 dark brown and 5 yellow-seeded plants; 8 of the dark-seeded plants proved heterozygous, segregating into 634 dark brown and 187 yellow-seeded plants. The numbers obtained from 29 other plants were 1,463 dark brown and 460 yellow-seeded plants.

Dark brown seed × Pale brown seed—flowers blue.

F_1 had a dark brown seed indistinguishable from the dark parental type. The numbers obtained from 19 segregating plants were 409 with dark brown and 136 with pale brown seeds.

Blue flower, pale brown seed × White flower, yellow seed.

F_1 had normal blue flowers and pale brown seeds. The numbers obtained from 30 heterozygous individuals were 1,657 plants, blue flowers with pale brown seeds, and 547 plants, white flowers with yellow seeds.

The results of these three crosses indicate a single factor difference for seed-coat colour on the assumption that the yellow seed only occurs in the absence of flower colour.

Blue flower, pale brown seed × White flower, dark brown seed.

F_1 had the blue flowers of one parent and the dark seed of the other. Twenty-nine F_2 plants raised showed—17 blue flowers, dark brown seeds; 3 blue flowers, pale brown seeds; 8 white flowers, dark brown seeds; and one white flowers, yellow seeds. Ten individuals from the plants with blue flowers and dark brown seeds segregated into—445 blue flowers, dark brown seeds; 120 blue flowers, pale brown seeds; 124 white flowers, dark brown seeds; and 48 white flowers, yellow seeds. The progeny of 32 other artificial crosses segregated into—327 blue flowers, dark brown seeds; 130 blue flowers, pale brown seeds; 108 white flowers, dark brown seeds; and 35 white flowers, yellow seeds. This clearly indicates a dihybrid cross supporting the assumption that the yellow seed is a pale brown with pigmentation inhibited by the absence of flower colour.

In the linseeds studied in the Central Provinces there is thus present a factor for petal colour in whose absence the petals are white, and a factor for seed-coat colour in the absence of which the seeds are pale brown. If the factor for petal colour is absent, however, the seeds are yellow.

Analysis of the oil-content of the seeds showed a higher percentage for white-seeded selections, averaging 41·37 per cent. against 38·62 per cent. in the dark-seeded selections. Against this advantage the acre yield of blue linseeds with dark seeds was distinctly higher than those with white flowers.

KIKUYU (*PENNISETUM CLANDESTINUM*): A NEW PASTURE GRASS FOR INDIA.

BY

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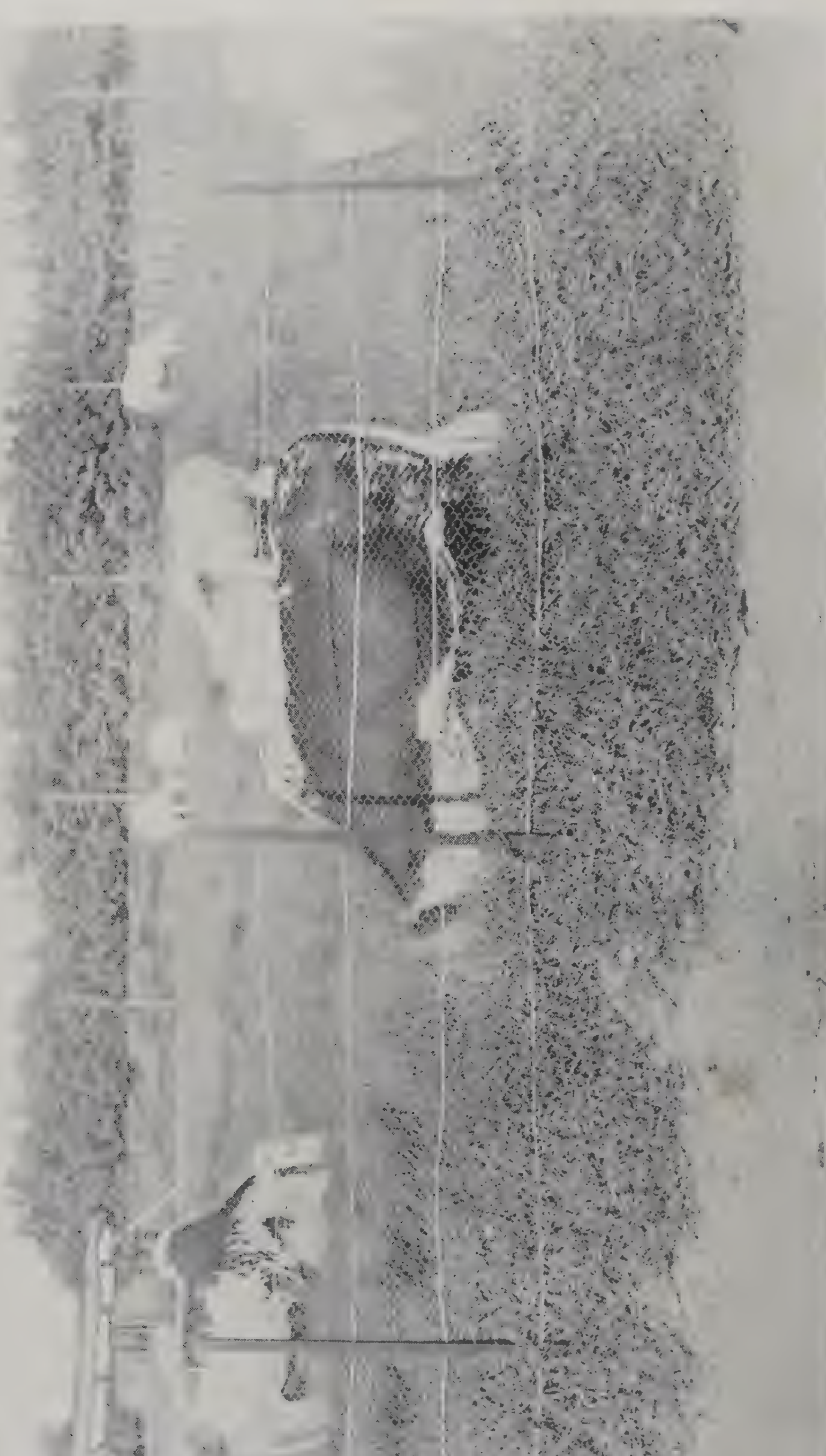
"HAVE you got Kikuyu"? every one asked me as I travelled through South Africa in quest of new plants and agricultural instruction. The botanists told me it had been brought to the Union from British East Africa only ten years ago; that it was a nutritious perennial running grass of extraordinary vigour, with rhizomes thick as a lead pencil and abundance of broad tender blades. Most remarkable of all was the fact that Kikuyu was not known to have produced seeds. The agriculturists said it was a splendid permanent pasture grass on good land; that it required an occasional top dressing of manure and, like all other grasses which throw out abundant root stocks, Kikuyu was liable to become sod-bound, and must therefore be cut-up by the plough once in two or three years. Where Kikuyu was established, no other grass could exist in the field. It was drought-resistant in a remarkable degree; all kinds of stock liked the grass. The horticulturists were no less generous in their praise of Kikuyu than the botanists and agriculturists. Kikuyu was the perfect lawn grass, not for the tennis-court, the hockey, the football or the polo fields, but for breadths of bright green, dense, soft mown grass. On an established Kikuyu lawn, the feet were said to sink in the delicious sward: Kikuyu was a grass to roll on. In the Cape Province, in the Orange Free State, in the Transvaal, in Natal and Zululand I saw Kikuyu at many farms and around public buildings well worthy of the eulogy I had heard bestowed upon it; but it was at Pretoria in the delightful grounds of the Union Buildings that I first looked on really extensive breadths of Kikuyu. Over all the beautiful

PLATE IV.



ON KIKUYU: "THEIR HEADS NEVER RAISING".

lawns there appeared to be no weed or grass of any description in the emerald green Kikuyu. It was almost with a twinge of jealousy I saw the loveliest lawns of England rivalled here in South Africa.

On the return voyage to India I carried with me a turve of Kikuyu. Apparently more dead than alive, it was planted in a rich bed at the Peshawar Agricultural Station on 3rd September, 1921. Before the first touch of frost in December, the grass had made extraordinary good growth and covered four square yards of land. A slight protection of branches was then given, and the grass came through the cold months of January and February without suffering more than a check in its growth. In April the runners, rooted and unrooted, were divided into six-inch lengths and planted three feet apart each way on half an acre. In four months' time the area was closely covered by Kikuyu, and sheep and cattle were put to graze on it (Plate IV).

In December the more vigorous, soft runners were injured when the mercury fell to 28°F. ; the grass was browned and growth ceased, but Kikuyu was otherwise uninjured. With the first warm breath of spring the grass sprang into vigorous growth again.

Two-thirds of the area has been regularly grazed by the farm stock, the remainder has been allowed to grow that the habit and nature of Kikuyu might be studied.

From the comparative table of chemical analyses quoted below from the *Union of South Africa Dept. of Agri. Leaflet No.* 45, it will be seen that Kikuyu compares very favourably with lucerne and other more well known grasses in this country :—

	Moisture	Crude protein	Carbohydrates	Fat (ether extract)	Crude fibre	Ash	Containing true protein	Nitrogen	Albuminoid nitrogen
Kikuyu (Air-dried) ..	8·29	12·36	35·06	1·79	33·08	9·42	8·31	19·770	1·330
Kikuyu (Green) ..	76·09	3·63	9·26	0·51	7·91	2·60	2·22	0·579	0·356
Lucerne (Hay)	8·00	15·50	30·60	2·40	34·80	8·90	..	..	..
Teff (Hay)	8·20	6·00	43·20	1·10	34·80	6·70	..	..	..
Rhodes-grass	9·00	9·20	29·30	1·40	42·50	8·70	..	..	..
Guinea-grass	8·02	9·03	28·63	1·68	40·54	12·10	7·09	1·445	1·134

Kikuyu is worthy of a trial in any part of India where the average annual rainfall exceeds 20 inches, or irrigation is available. As it does not produce seeds there is little danger of the grass spreading to fields whereon it might be undesirable. Kikuyu may go a long way in helping to provide really good nutritious grazing for the dairy cattle in India, for wide sweeps of lawn or for the race course. It is probable that it will prove superior to *dhub* (*Cynodon dactylon*).

THE PROBLEM OF POTATO STORAGE IN WESTERN INDIA.*

BY

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THE study of the storage rots of potato has been carried on in the laboratory of plant diseases at the Poona Agricultural College, with some interruptions, since 1917. It is proposed in this paper to discuss the bearing of the main conclusions reached on the problem of potato storage in Western India, the detailed experimental evidence in support of the conclusions being reserved for separate publication.

PREVIOUS WORK ON THE PROBLEM.

The problem of potato storage has always been one of great importance since the introduction of potato cultivation in Western India. Considerable losses in storage occur due to various causes. One of the most recent estimates of such losses made from actual observations on cultivators' stores puts down the loss at between 50 and 75 per cent.[1] The potato moth (*Phthorimea operculella*) is the most obviously visible of the pests and diseases of the potato tuber, and it is not surprising that it had been for many years regarded as the most important of the potato troubles in Western India. A considerable amount of work was done on it by the Bombay Agricultural Department between the years 1906 and 1912, resulting in the discovery of fumigation with petrol as an efficient and practicable remedy.

The moth trouble, however, is not the only one causing damage in potato storage. Bacteria and fungi, either independently or

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* Paper read at the Indian Science Congress, Lucknow, 1923.

[1] Kasargode, R. S. *Proc. Third Ent. Meeting, Pusa*, 1919, p. 764.

following in the wake of the caterpillar of the potato moth, cause quite considerable, and sometimes even greater, damage. This was strikingly brought out in an experiment conducted by Mr. Ramrao S. Kasargode, Assistant Professor of Entomology, Poona Agricultural College, in 1912, in which it was found that, in spite of fumigation which excluded the potato moth, as much as 55 per cent. out of a lot of 5,000 lb. tubers were destroyed by rotting within a period of three months.[1] The investigation of this particular case of rotting was carried out at Pusa by Hutchinson and Joshi[2] and led to the discovery of two kinds of bacteria which are capable of invading the living potato tuber under certain conditions and causing it to rot.

The acuteness of the potato storage problem was not, however, fully realized until, owing to the Great War, the import of Italian seed tubers was stopped and cultivators in Western India were awakened to the necessity of becoming independent of foreign supplies in respect of seed tubers. This was the origin of the investigations on potato cultivation in Western India by Dr. H. H. Mann and others, the results of which are published in *Bulletin* 102 (1920) *of the Bombay Department of Agriculture.* Chapter IX of this Bulletin deals with the storage of potatoes, and the authors (Mann and Nagpurkar) have come to the conclusion that the " vital factor in the potato problem in Western India " is a form of rot which they term " heat rot " and which they regard as identical with the " black heart " described by Bartholomew[3,4] and Stewart and Mix[5] in America. The " heat rot " is believed by Mann and Nagpurkar to be caused by mere physical heat and to have nothing to do with parasitic organisms and it is said to occur whenever the temperature of storage rises above 90°F. On the basis of this belief these authors recommended a system of storage[6]

[1] Kasargode, R. S. *Ibid.*

[2] Hutchinson, C. M., and Joshi, N. V. *Mem. Dept. Agri. India, Bact. Ser.*, I, No. 5, 1915.

[3] Bartholomew. Black heart of potatoes. *Phytopathology*, III, 1913, pp. 180–182.

[4] Bartholomew. A pathological and physiological study of the black heart of potato tuber. *Centralblatt Bact. Parasit Infect.*, 43 Bd., Nos. 19–24, 1915, pp. 609–639.

[5] Stewart and Mix. *N. Y. Agri. Expt. Sta. Bull.* 436, 1917.

[6] *Bomb. Dept. Agri. Bull.* 102, p. 96, 1920.

the essentials of which are (*a*) fumigation with petrol, (*b*) rigid sorting to remove injured or diseased tubers, (*c*) storing in bags in a godown where the temperature is maintained below 90°F., and (*d*) periodical inspection of bags. It is claimed that by this system "potatoes kept for seed can be maintained without anything like the serious losses which have often, if not usually, been incurred in the past."

In actual practice, however, this system has not been found to fulfil its promise to solve the potato storage problem in Western India. Mann and Nagpurkar[1] give no information as to the actual results obtained in the improved storage house described by them. Presumably, at the time of publication of their Bulletin, no actual storage had been done in the storage house constructed according to their design on the premises of the Poona Agricultural College. The Economic Botanist to Government, Bombay, however, writes in this connection in his Annual Report for 1920-21[2] that "it has been possible to keep the temperature (of storage) down to an average maximum of 85·9°F. during May by quite crude methods but still there has been much loss in storage. This question needs more study." The rotting material from this storage was examined from time to time in the laboratory of Plant Pathology at the Poona Agricultural College and symptoms of the so-called "heat rot" were frequently noticed, indicating that they might occur at temperatures lower than 90°F.

The need for more careful study of the potato storage rots had also become obvious from the constant association of certain fungi and bacteria, each with characteristic effects, with certain types of rotting in tubers received for examination. Certain striking discrepancies between the descriptions of "heat rot" of Mann and Nagpurkar and those of the "black heart" of American authors also suggested a confusion of causes and effects and necessitated a careful study of the relative responsibility of physical heat and micro-organisms in the causation of potato rots.

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[1] *Bomb. Dept. Agri. Bull.* 102, pp. 95–96, 1920.

[2] *Ann. Rept. Dept. Agri., Bombay,* 1920-21, Appendix I, p. 114.

CONCLUSIONS FROM THE WRITER'S WORK ON POTATO STORAGE ROTS.

The studies just alluded to have been carried out during the past few years by the present writer and the main conclusions reached may be briefly stated as follows :—

(*i*) The storage rots of potatoes as distinct from the moth trouble may be divided into two classes :—(1) Dry rots caused by fungi and (2) wet rots caused by bacteria.

(*ii*) Of the fungi, four different kinds were found responsible for potato rots, two species of *Fusarium* and two species of *Sclerotium* (*Sclerotium Rolfsii* and *Sclerotium* sp. hitherto known as *Rhizoctonia destruens* and *Rhizoctonia Solani* respectively). The identification of these fungi is not yet complete.

(*iii*) Unaccompanied by bacteria, each of the above fungi produces a characteristic form of dry rot, but the individuality of the rot is often lost owing to bacterial invasion and it ultimately becomes a wet rot, especially at higher temperatures (between 86°F. and 100°F.).

(*iv*) All these fungi appear to attack the potato tuber ordinarily through wounds in the skin. But they may also find admission, though less frequently, through lenticels and through the interruptions in the skin in the neighbourhood of the eyes.

(*v*) All these fungi grow fairly well between temperatures of 77°F. and 95°F., though the optimum is different in different cases.

(*vi*) The wet rots are caused by a number of forms of bacteria, and on two occasions (1912 and 1918) on which samples of rotting tubers were sent to the Imperial Bacteriologist, Pusa, for examination, the same or very similar organisms were found to be responsible. These are common soil organisms and as such probably invariably present on the surface of tubers and are capable of causing rots in living potato tubers under certain conditions of temperature and moisture. The optimum temperature for the growth of these is between 86°F. and 104°F.[1]

(*vii*) The " heat rot " described by Mann and Nagpurkar is only a form of bacterial wet rot and the symptoms included in this

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[1] Hutchinson, C. M., and Joshi, N. V. *Ibid.*

term, viz., blackening and softening of the flesh of the tuber and exudation of watery matter and foul odour, have been found to occur only in the presence of bacteria. These symptoms are *not* produced when micro-organisms are successfully excluded and heat alone up to 42°C. (107·6°F.) is allowed to act on potato tubers constantly for a period of nine days at least. On the other hand, these symptoms may be produced at temperatures as low as 81°F. when the appropriate micro-organisms are present. Heat by itself cannot, therefore, be regarded as a primary cause of potato rots, as supposed by Mann and Nagpurkar.

(*viii*) The symptoms described as " heat rot " are quite distinct from those of " black heart " as will be seen by careful comparison of figures and description of the Indian and the American authors.

(*ix*) There is reason to suppose that continued exposure to high temperatures like 104°F. might eventually kill the eyes and tissues of potato tubers sooner or later and render them liable to attack by saprophytic organisms, some of which are known to become pathogenic at temperatures of about 95°F. It is in this sense that heat by itself might be a primary cause of potato rots. There is also the possibility of an excessive rise of temperature in potato heaps due to respiration and action of micro-organisms, as was found by Cotton and Taylor[1] in potato clamps in England. Mann and Nagpurkar,[2] however, did not find the temperature rising higher than 93°F. in the potato heaps in Western India with their special cooling arrangements, and it is unlikely that physical heat by itself is a primary cause of potato rots in Western India.

The bearing of the above conclusions on the problem.

The problem of potato storage in Western India is, in the light of the above conclusions, rather more complex than has been supposed by Mann and Nagpurkar. It is not sufficient to keep the temperature of storage down to 90°F., for at temperatures between 80°F. and 90°F. the organisms found associated with potato rots thrive

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[1] Cotton, A. D., and Taylor, H. V. The causes of decay in potato clamps. *Supplement No.* 18 *to Jour. Bd. Agri., London,* March 1919, pp. 54–58.

[2] Mann and Nagpurkar. *Ibid.,* pp. 89–90.

specially well. In devising measures against potato rots, therefore, it is necessary to have regard to the biology of the respective organisms concerned and to endeavour to prevent, first, infection by these organisms and, second, their spread. How far this is feasible will now be discussed.

Prevention of infection.

During the course of the work on potato rots one fact was brought out prominently, namely, the existence of a widespread infection of potato tubers with one or more of the rot causing organisms already before the tubers went to the storage house. It has been quite a common experience to find some of the tubers selected as apparently healthy to serve as controls in the inoculation experiments developing one or more of the rot causing organisms during the course of the experiments in spite of all surface disinfection. This experience agrees with that of American workers stated in summary by W. A. Orton[1] of the U. S. Department of Agriculture in the following words :—

"We are coming to realize more and more.................. that we have to deal primarily with a condition of general soil infection and that the planting of healthy seed is by no means an insurance of a healthy crop."

Although the corky skin of the potato tuber, if uninjured, ordinarily prevents the entry of pathogens successfully, still there are solutions of continuity of the skin in the neighbourhood of the "eyes" and in the innumerable lenticels which occur on the potato tuber and afford points of entry to rot causing organisms, which are present in the soil. Hence the widespread infection already present in the tubers before they go to the storage.

To prevent this kind of infection, extensive sterilization of the soil would be necessary, but apart from the expensiveness of soil sterilization, any method of sterilization by heat or by use of poisonous substances would probably destroy the useful

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[1] New work on potato diseases in America (paper contributed to the International Potato Ronference, London, 1921).

micro-organisms along with the harmful ones and what might be gained in freedom from diseases might be lost in fertility.

Future work on this subject, therefore, must be directed towards finding out the best methods of controlling soil infection by cultivation methods and by the study of crop rotations. At present it must be admitted that we do not know of any satisfactory methods of preventing infection of potato tubers in the soil.

Prevention of spread in storage.

In the prevention of spread in storage, two lines of attack are feasible. One is to destroy the rot causing organisms in and on the tubers before putting them in the storage and the second is to so arrange the conditions in the storage house that the organisms would find them unsuitable for growth and spread. Various fungicides have been tried with varying degrees of success depending on the extent to which the tubers had been already infected before the treatment. In general, it may be said that while fungicides like copper sulphate, mercuric perchloride and formalin are effective to some extent in destroying the organisms at or near the surface of the tuber, not one of them is capable of ensuring perfect sterilization, if the organisms have already penetrated to some depth below the surface. Hutchinson and Joshi[1] recommended the treatment of seed tubers with copper-sulphate solution (2 per cent. for 30 minutes) ; and in their own experiments they seem to have got results which indicate the effectiveness of this fungicide in preventing infection by rot causing bacteria, especially when care is taken to remove all injured tubers and the moisture in storage is kept at a low degree. But in both Mann and Joshi's[2] experiments and in our own, it has been found that surface sterilization with copper sulphate has not been sufficient to prevent rotting in every case and the same experience was obtained on a fairly large scale by Mr. Ramrao S. Kasargode, Assistant Professor of Entomology, Poona Agricultural College, in the hot weather of 1913 when he

[1] Hutchinson and Joshi. *Ibid.*

[2] Mann and Joshi. A chemical study of heat rot. *Appendix to Bom. Dept. Agri. Bull.* 102, 1920.

stored about 4,000 lb. of tubers after treatment with copper sulphate in thin layers on racks in a well ventilated room. Practically all the tubers showed the characteristic bacterial rot. Still the method suggested by Hutchinson and Joshi may be found useful by potato growers who wish to preserve a small quantity of seed tubers for their own use, especially if practised immediately after harvest, before the micro-organisms have had a chance to get inside the tubers and beyond the reach of the fungicide.[1] Formalin treatment cannot be recommended, both because it will be more expensive and because its effect is not likely to be so lasting as that of the copper sulphate treatment. Mercuric perchloride is a dangerous poison and as it has been shown by Güssow and Shutt[2] that 3 lb. of potato tuber (13 tubers) treated for 3 hours with 1 : 2,000 corrosive sublimate solution will take up from the solution 0·05 grm. of $HgCl_2$, which is six times the maximum official dose in medicine, potatoes so treated must become non-edible. For this reason, as also for the ineffectiveness of even this powerful fungicide against organisms already inside the potato tuber, the use of mercuric perchloride in preventing potato rot cannot be recommended.

As regards controlling the conditions of storage so as to reduce the chances of growth and spread of organisms already present and to prevent infection, the knowledge we have gained of the physiology and parasitism of the rot causing organisms indicates the methods likely to be successful. It is common-place to say that potatoes or, for the matter of that, anything liable to rot, must be stored in a cool, dry and well ventilated place. Of these conditions of storage the temperature is perhaps the most important and is so recognized by cultivators, who have devised elaborate arrangements to bring about a reduction of temperature of storage. One such method in vogue in the Khed Taluka of Poona District has been described by Mann and Nagpurkar[3] by which the temperature can be kept at from 86°F. to 93°F. This method has been improved

[1] The importance of immediate (i.e., within 24 hours after digging) disinfection of potato tubers is brought out by O. A. Pratt's trials with $HgCl_2$ and formalin in the control of the powdery dry rot of potatoes caused by *Fusarium trichothecioides*. *Jour. Agri. Res.*, VI, 830, 1916.

[2] Güssow, H. T. *Canada Expt. Reports*, 1912, pp. 200-202.

[3] *Bombay. Dept. Agri. Bull.* 102, pp. 33-34, 1920.

upon in the storage house built by Messrs. the Union Agency of Bombay in their potato works on the premises of the Poona Agricultural College.[1] The temperature in this has been kept as low as 82°F. and the ventilation is also much freer than in the ordinary cultivator's storage. But both these methods of storage have the disadvantage of a high degree of moisture which is an inevitable result of the use of evaporating water in each of these methods as a means of reducing the temperature ; and although, under favourable conditions and with good care in the sorting preliminary to storage, very good results have been occasionally obtained, reducing the loss due to rots to as low as 2 to 5 per cent.,[2] yet these good results are not obtained with certainty and serious losses may occur even in such methods of storage. Such success as was obtained in these storages would seem to be due to the careful sorting out and rejecting of infected and injured tubers and not to the temperature of the storage. For, while the low temperatures reached seem to keep some of the wet rot causing bacteria fairly under control, these same temperatures are found most suitable for the growth of other organisms, particularly the fungi *Fusarium* sp. and *Sclerotium Rolfsii.* This explains the observation of Mann and Joshi that, with a temperature of storage below 85°F., " the attack of *Fusarium* dry rot went on increasing,"[3] and the experience of Mann and Nagpurkar that " storage in Poona in the cold weather for two months at about 80°F. means the loss of over 80 per cent. of the stored potatoes (in some cases)."[4]

Further experiments with methods of storage would seem, therefore, desirable, and in conducting these, the temperature and moisture relations of the various organisms will have to be borne in mind. It has been found that the dry rot *Fusarium* fungus and the fungus *Sclerotium Rolfsii* grow best at temperatures between 25°C. and 30°C., but that they also grow fairly well at the lower temperature of 20°C. ; this would suggest that the temperature of storage must be at least reduced to 20°C. Indeed American writers[5]

[1] *Ibid.,* pp. 95-96.
[2] *Ibid.,* pp. 92-93.
[3] *Ibid.,* p. 95.
[4] *Ibid.,* p. 67.
[5] Pratt, O. A. Control of the powdery dry rot of Western-potatoes caused by *Fusarium trichothecioides. Jour. Agri. Res.,* VI, 1916.

recommend as low temperatures as 2° to 4°C. to prevent losses from *Fusarium trichothecioides*, which is a dry rot fungus very similar to, if not identical with, our own dry rot *Fusarium*. If such low temperatures are found absolutely necessary to solve the potato problem of Western India, then the cold storage methods in Western countries will have to be adopted in this country also.

It seems doubtful, however, if the resort to cold storage would pay in connection with a crop which covers only about five or six thousand acres in Western India, which is used as a more or less fancy vegetable and not a staple article of diet, and which is generally sold off by the growers immediately after harvest. The losses in storage, so far as they occur, are easily made up by the potato merchants by increase in price, which, in that case, affects only a comparatively small section of well-to-do buyers in a few big cities. Even in Germany[1] where the potato crop in 1912 covered an acreage of 8,165,000, and where it forms not only an important staple crop for stock feeding and human consumption, but also an important raw material for certain chemical industries, a 10 per cent. loss by decay which occurs every year on an average is apparently considered negligible. If, therefore, by the systematic and continued use of the comparatively simple precautions, namely, (1) rigorous sorting, fumigation and rejection of all diseased and bruised tubers, (2) careful storage in bags, (3) keeping down the temperature of storage below 90°F., the losses can be kept down below 10 per cent. as has been claimed by Mann and Nagpurkar,[2] cold storage would seem unnecessary for the conditions in Western India. The removal of injured and infected tubers in the preliminary sorting would considerably lessen the chances of subsequent infection in the storage, the rot producing fungi being ordinarily wound parasites. These precautions together with improvements in the storage house designed to reduce the temperature without increasing the moisture should enable us to finally solve the problem of storage of potatoes in Western India.

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[1] Orton, W. A. *U. S. A. Dept. Agri. Bull.* 47, 1913.

[2] *Ibid.*, pp. 108-109.

PROTECTION OF CABBAGE AND KNOLKHOL SEEDLINGS FROM FLEA-BEETLES.

BY

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THE growi of vegetables for the market, and particularly the cultivat bage, knolkhol and other similar plants, is beset wit ties, but there are few which are more annoying n the way in which the young seedlings are seed-beds by several insects, of which by far the re the flea-beetles. The present note deals with in the Konkan near Bombay to check the damage milar pests.

les are small bluish-coloured beetles, which, being owerful hind-legs, jump when disturbed almost as as, from which faculty their name is derived. be many species of these in India, but most of een identified, and about their life-history little is known. As the seedlings of many vegetables grow these beetles are often found in multitudes feeding on the leaves and leaving behind them numerous small round holes. The tender seedlings so attacked generally die.

The measures previously adopted against these and similar seedling pests have chiefly consisted in collection of the insects by hand, spraying with kerosine emulsion and dusting of the plants with ashes previously treated with kerosine. Such remedies were tried in the present experiments but, when the pest was bad, none of them was satisfactory. Spraying and dusting of seedlings in seed-beds is in any case not very satisfactory as the frequent

necessary watering tends to remove the materials from the leaves. When the insects are present in large numbers, collecting by hand or bag proved almost impracticable.

Two new methods were therefore tried. As the area of seedlings is usually small, it was suggested that the whole of the seedling area should be enclosed by a fine-meshed curtain like a mosquito net. Two seed-beds, each three feet square, were prepared and sown with knolkhol seed. One was completely protected by a curtain as described fixed on a bamboo frame, and about eighteen inches high. The lower sides of the curtain were weighted down with stones. The net was easily removed for watering and was then immediately replaced. The result was excellent. No attack took place, while in a similar seed-bed without protection the plants were miserable, stunted and several times smaller than those inside the net. The inevitable interference with the light inside the net did not seem to have any serious effect on the character of the seedlings after transplanting.

The second method tried was by trapping the flea-beetles on a sticky plate. It was suggested by the success which had been obtained in trapping mango-hoppers on trees by means of a sticky mixture of oil and resin. A rectangular tin plate, two feet long and eighteen inches wide, with a handle at the back for holding, was used in the present experiment. This was painted on the lower side with a sticky mixture prepared from boiled *undi* oil (*Calophyllum inophyllum*) (1 part) and fairly powdered resin (2½ parts). Any other similar oil would probably have given the same results, but the proportion of resin necessary to keep the mixture sticky would have to be worked out in each case. The tin plate so prepared is held over the infested seed-bed, and the plants gently brushed. The insects when disturbed fly up and are caught on the sticky tin plate. If this brushing is repeated on four or five successive days, the infestation can be almost entirely removed. If necessary, it can, of course, be continued longer. After three or four days, the sticky mixture dries up, but a few minutes' exposure to the sun will make it as sticky and effective as before. The experiments with this method turned out a complete

success and the damage by flea-beetle was reduced to very small dimensions.

In actually carrying out the first of the methods above suggested, a kind of coarse woven cloth, locally available in the market, was found to be satisfactory. A piece ten feet long and thirty inches broad cost about a rupee. Three such pieces will cover a seed-bed covering forty square feet, the cost for making the complete net being only eight annas. Thus at a cost of Rs. 3-8-0 a seed-bed will be protected sufficient to plant out one-eighth of an acre and the curtains will last for four or five years. This will save an annual large loss in these expensive vegetable seeds, with a guarantee that the seedlings will be ready when wanted.

The second method will only cost eight annas for making the tin plate with four annas for the mixture. By the use of this it is possible to clear seed-beds sufficient to plant out one acre of cabbage or knolkhol.

A FEW OBSERVATIONS ON PADDY (*ORYZA SATIVA*) CROSSING.*

BY

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The paddy spikelet or flower offers some difficulties in successful crossing. Experience showed us that special methods must be employed in successfully crossing it. As a result we gradually evolved a method which is now nearly cent. per cent. successful. To understand the difficulties and to learn how they have been overcome, one must first learn the mechanism of the paddy flower.

The paddy flower is composed of two short empty outer glumes usually not more than one-third the length of the inner glumes. They are of no account in paddy crossing, for they neither help nor retard the crossing in any way.

The inner glumes are generally two in number and though not differing from each other in size and texture, one of them (the third as it is called) is five-nerved and bears at its apex an awn in all awned varieties of paddy. The other (fourth glume) is three-nerved and when removed bears away with it the ovary, the stigmas and a few of the stamens. The two inner glumes between themselves enclose the paddy grain. Inside the inner glumes are two broadly oval, small, thick, fleshy bodies, the lodicules. They play an important part in the opening of paddy flowers.

The stamens are six in number. All are well developed fertile and functioning. In a mature spikelet held to light, they are seen to occupy about half the length of the entire spikelet.

The ovary is unicellular†, a little longer than broad, smooth and bears at its apex two styles with feathery stigmas.

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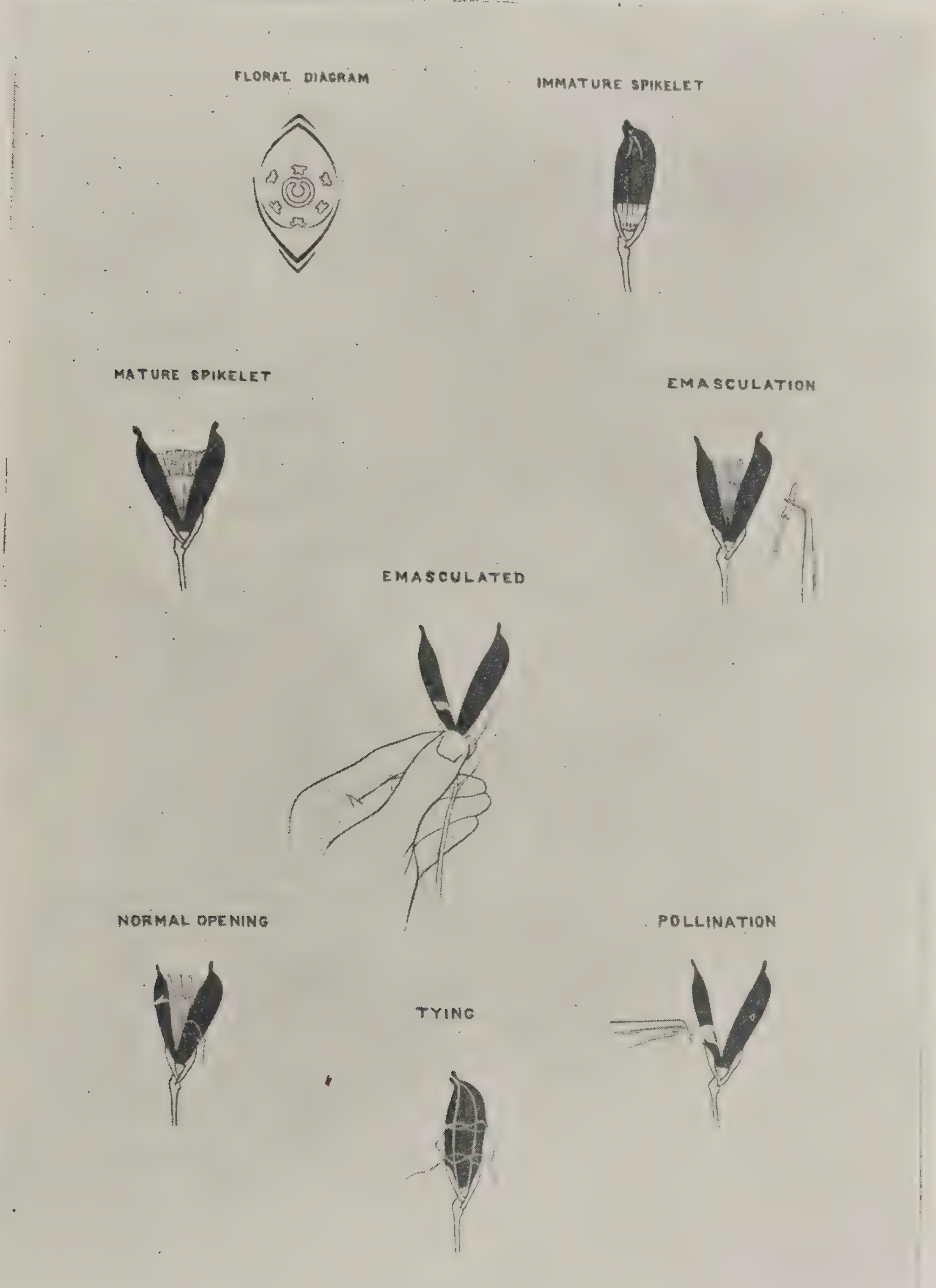
* Paper read at the Indian Science Congress, Lucknow, 1923.

† In the double-rice paddy, however, the ovary may be bi-, tri-, or quadri-cellular, the number of styles then becoming double the number of cells present in the ovary.

The mistake that one is likely to make in crossing paddy is to consider the glumes as functioning the same as they do in the



case of wheat. In crossing wheat the glumes are usually snipped off with a pair of fine scissors before emasculation. The same

procedure cannot be followed in the case of paddy, because the glumes are delicate, protective in function and form a part and parcel of the mature seed. If they are injured in any way likely to set up withering, the seed does not set.

Paddy anthers usually burst just a little before the flower opens. We found by actual experience that emasculation must be done at the latest two hours before the flower opens. The two glumes are very gently pulled apart with fingers—no forceps should be used—and the stamens removed with a pair of fine bent forceps. About two hours later when paddy flowers begin to open, the emasculated flowers are pollinated and the glumes are closed and tied up with a piece of fine silken thread. The tying helps to keep the glumes in their natural position. If the glumes are not tied up, they do not close properly and the percentage of successful crosses diminishes greatly. The tying up also does the work of bagging and no further bagging is necessary.

The time at which the flowers open differs with the time of the year when the paddy plant flowers. For instance, *aus* or early paddy, which is sown in April-May and flowers in July-August, opens at about 7 a.m., while the *sail* or transplanted paddy which flowers in October opens at about 9 a.m. Weather conditions at the time of flowering affect a good deal the time of opening, sunshine hastening the process and clouds and rain retarding. It has been found possible to cross the *aus* with the *aman* or *sail* paddy and the *aman* again with the wild paddy, and some of the resultant crosses are yielding very interesting results. If it is intended to cross *sail* paddy with *aus* paddy under ordinary field conditions, it is more convenient to grow the *sail* paddy in its proper season, and to grow the *aus* paddy out of its season, for the *aus* can be made to grow and flower during the *aman* season while the *sail* paddy cannot be made to flower during the *aus* season. In crossing with the wild paddy it is important that the *sail* paddy should be used as the female parent and the wild paddy as the male, because the wild paddy spikelets shed before the grains mature. If the wild paddy is used as the female parent the crosses are shed before they are ripe, and are thus lost.

Selected Articles

METHODS OF PLANT BREEDING IN GENERAL.*

BY

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UNDERLYING improvement of different crops are some fundamental processes. These do not vary, essentially, when applied to individual kinds. Variation lies merely in details which are learned only through experience. Given a basic understanding of the essential phases of plant breeding, one should not find it hard to develop a method of improvement applicable to a particular kind of material.

Methods classified.

The various methods of plant amelioration may be classified under three main groups: namely, (1) selection, (2) hybridization, and (3) hybridization combined with selection.

(1) SELECTION.

Too often, the term, "selection," as a method of improvement in Genetics, is confused with other processes to which selection is popularly applied. For example, it has been taken to mean varietal selection, that is, the choice and use of the best variety. Varietal selection within a species is indeed expedient especially when thousands of varieties exist. For, the elimination of those varieties which are not profitable to raise will improve the average yield of the varieties or the species. However this does not fall under genetic selection. Neither does selection mean in cereal

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improvement the selection of the largest or the heaviest seeds although, again, it must be said that increased yield may be obtained by such a practice, for, in whatever way the biggest or the heaviest seeds be obtained—by hand picking or by the use of a fanning mill or by soaking the seeds in a brine solution where only the heaviest will not float, thus allowing their separation from the lighter ones—the seeds are freed from broken individuals and weed seeds. Weed seeds in the seed mean more expense in weeding and cultivation of the field, less moisture and food for the plants, and less yield and money for the farmer. Also, the larger and heavier seeds contain more stored food material for the embryo than the lighter and smaller ones, and under unfavourable conditions they are more likely to survive. Except these advantages, it is very doubtful, as far as yield is concerned, if the large and heavy seeds have any superiority over the smaller and lighter ones.

It should be borne in mind that seed selection, as the term is used in Genetic literature, does not mean just selecting seeds, which are free from disease or other physical defects. True, the use of no seeds but those disease-free is to be preached, indeed this must be the practice on every farm, for it may happen that the disease on the seed will appear on the plant which grows therefrom. This would mean a diseased field which means poor yield and a loss to the farmer. But even when only the best variety is grown, and only seeds which are free from broken grains, from weed seeds and from diseases are used, there remains the fact that the yield may be poor, unless genetic selection, or strain selection, is practised.

The reader doubtless knows the meaning of the sayings, " It is the blood that counts," and " One is of bad ancestry." We can just as truly say, " It is performance that counts." When we desire to improve a given variety of plant by improving its yield through selection, what is really desired is to free a given stock from such blood, or strains as is responsible for low yield, and to obtain only plants that are high and superior yielders. But it is usually impossible to tell from the appearance or from the size or weight of a seed whether the plant which it will produce will

be a poor yielder or a heavy yielder. In a given number of seeds from unselected plants, a plant from a large seed may actually yield less than a plant from a smaller seed. The appearance of seed should serve only sometimes as a guide in the selection of initial parent plants. The appearance of the plant does not always tell what kind of yield its progeny will give. Under certain circumstances, such as when a plant has more fruits than another because of more favourable soil conditions, the progeny of this more favoured plant, on account of less fertile soil, may actually yield less than that of the poorer looking individual. Since neither the appearance nor weight of a seed nor of the plant will tell us exactly what kind of yield the progeny will give, the final judgment of the yielding power must be based on the ancestry of the seed or plant or on the plant's performance—on what it actually does. An example may make this point clear. Suppose, to improve the Filipino race it is desired to enact immigration laws that will prevent the entrance of feeble-minded strains into this country. These laws will prevent admission of immigrants which are feeble-minded, assuming that in this way the " blood " which carries feeble-mindedness will be excluded. But this assumption will not always hold good for even if one be not feeble-minded, he may be a carrier of defective germplasm which bears the determiners for feeble-mindedness and, if allowed to reproduce, may in time be the parent of feeble-minded children. The prevention, therefore, of the entrance of feeble-minded " blood " into the Islands could not depend only upon the appearance of the incoming immigrant but also on his ancestry, just as the hereditary yielding capacity of a grain or seed is best judged from the performance of its parent plant. In brief, then, proper selection is to be based not on appearance alone, but on performance also. This being true, to get any maximum improvement of the yield of a variety ultimately consists in the isolation of the *best single* strain in that variety.

Selection may be of different kinds: (*a*) mass selection, (*b*) line selection, (*c*) clonal selection, and (*d*) bud selection.

(*a*) In *mass selection* we proceed somewhat as follows: Bearing in mind the object of the selection, individuals are selected on

the basis of this object and then are planted in a mass. Selection must be made intelligently, in the manner and at such time as will insure the best results. Oftentimes, this cannot be done except in the field when the crop is mature. We may illustrate this with corn. If the object of selection is to improve the yield, intelligent selection of seed ears is not made in the pile, for here we have no way of knowing which ears come from high yielding strains and which come from the inferior sorts. Sometimes superficial examination is sufficient to enable one to choose the desirable individuals. Sometimes, however, different methods of analysis are employed to decide which plants are to be selected and which are to be discarded. Chemical and other analyses are used; also the scale and balance; and the performance record is kept for several years.

For mass selection to be of the greatest value it must be continuous until the limit of improvement is reached. For purposes of demonstration or to determine if any progress and how much is being made, it is necessary to plant a check side by side with selection. The check consists of a portion of the original material. The material left after selection does not serve as a proper check, neither does a portion of the material from which the inferior strains have been taken away constitute a proper check.

In the absence of check cultures, the progress of selection may be determined by comparing the performance of the selected crop with the average performance of the variety for five or more years in the locality or region. When one is familiar with his crop and soil, it may be possible for him to tell when he is getting any improvement even if either the direct or the indirect check for comparison is lacking. However, this is true only under average conditions. If for any reason the crops suffer from unfavourable conditions and become abnormal, then it will be difficult, if not impossible, to diagnose progress.

When check cultures are run at the same time as the selection tests, one point should be borne in mind, and that is genetic contamination. The selected plantings should not be allowed to cross with the check or with any other material. For this reason it

is advisable to carry out the selection cultures in an isolated field and to screen them from the check by planting border plants several rows deep. These plants may be of the selection itself, in which case they should be discarded after harvest, or they may belong to another but faster growing species. Whatever is used, the screen must be effective. With tobacco, contamination is prevented by producing the seeds under bags.

When the plant is self-fertilizing and is not subject to any amount of cross-breeding, the precautions given above are unnecessary.

It should be emphasized here that in selection, the individual plant is the unit. This point is likely to be overlooked under certain circumstances. For instance, when several seeds of a crop are planted in a hill, the hill is sometimes taken as the unit. It is evident that, in so doing, the choice of individuals becomes a hit-or-miss affair. This is well illustrated and discussed fully under mass selection in rice.

The improvement in mass selection is obtained slowly and in this respect it is inferior to line selection. It has the advantage, however, of being practically non-technical and hence easy to use. Mass selection has been used with cotton, and with rice, corn, and other cereals.

(*b*) *Line selection* consists in the testing of the progeny of single individual plant. Le Couteur and Shirreif were the first to use this method. The progeny test was specially used by Louis Vilmorin and line selection is sometimes called the "Vilmorin Method."

The initial selection of plants in line selection does not differ at all from that of mass selection. Generally, however, fewer individuals are selected in line selection. The critical difference between the two methods is that in line selection the progeny of each selected parent plant is tested separately. The method of planting is often termed "head-to-the-row," "plant-to-the-row," or "ear-to-the-row," meaning that the seeds from one single head, plant, or ear are planted in one row. Not all the seeds from one plant need be planted, only sufficient to give a fair sample. One

hundred offspring are generally sufficient to represent the strain. When about 100 seeds are sown in a row, the method of planting is termed "cent-gener method." This was first used by Hays of Minnesota in grain breeding.

Each year, the most promising lines or strains are saved and tested. This is done until the few really superior sorts are discovered, or the best single sort, then the seeds of each line may be multiplied as fast as possible and introduced into the seed trade or into the general farming. The critical point in line selection is the isolation of the best single strain. It were better if we called the process, isolation. Strictly speaking, no further selection is necessary if the isolation is done properly. Of course, care must be taken that no seed of inferior race contaminates the improved stock.

Line selection has been the important method of plant improvement followed in the Swedish Seed Station at Svalof. Here the method came to be known as the "System Pedigree" or "Separate Culture."

Line selection is easily applicable to naturally self-fertilized plants or to those reproducing vegetatively. Among them there is practically no out-breeding. When applied to naturally cross-fertilized plants, selected parent plants should be guarded and prevented from crossing with any other plant in the same row or in another row. Either mechanical or genetic contamination by inferior strains will cause a gradual loss of improvement in proportion as the seeds of inferior quality supplant the improved ones. Moreover, the selected plants should be self-pollinated.

(c) *Clonal selection.* The term "clon," from which the adjective "clonal" is derived, is applied to a pure line produced asexually. We may conceive of a population consisting of a mixture of different clons (sometimes written "clones"). Improvement in this kind of population will be obtained by isolation or selection of the best clons or the best one of them. Within a clon itself, as within asexually produced pure line, heritable and desirable variations may arise and selection within this pure line will have for its object the isolation of those variations.

Common examples of clons are found in fields of potatoes, of abaca (*Musa textiles* Nee), of plant canes (distinguished from seedling canes), of ordinary plantings of cassava and pineapple.

(*d*) *Bud selection* is closely related to clonal selection. Bud selection has been used mainly in fruit improvement. It is generally known that bud mutations or bud sports occur in fruit trees. Many important commercial varieties of fruit existing at the present day originated as bud sports. The Washington navel orange is a familiar example.

In the Philippines, bud selection has a promising future. We practically have no seedless variety of any pomological crop. We are looking ahead to the day when one may eat the delicious lanzon without having to be bothered with its bitter seed. We anticipate similar improvement with mango, mabolo, and other fruits. Bureau of Agriculture officials verbally claim that there is now a seedless *duhat* (*Eugenia jambolana* Lam.) variety which is in the way of propagation.

(2) Hybridization.

Objects. Hybridization is performed with one of three main objects in view. These objects are : (*a*) To bring about increased variability, that is, to " break the type " ; (*b*) to get a combination of certain desirable characters ; and (*c*) to obtain increased vigour which is supposed to be due to heterosis, or the heterozygosity of the hybrids.

Aspects. When the object of hybridization is to test or further study any or all of the phases of the Mendelian laws of heredity or to obtain hybrids from parents of known purity it is a purely scientific aspect. In this kind of work control of parentage is important. Because the operation is quite technical and consumes a good deal of time, it cannot be done on a commercial scale.

Hybridization has also been performed for a purely commercial or utilitarian reason and without strict adherence to scientific precedents and procedures. The work of Burbank, of which more will be said later, as well as the work of horticulturists are good

examples of this phase of hybridization. For convenience, I will designate this kind of work as commercial hybridization.

Technique of hybridization (purely scientific). A prerequisite for this work is familiarity with the sexual group of plants and the pollination habits of the flowers.

Generally, plants may be classed under three groups: (*a*) Diœcious, (*b*) monœcious, and (*c*) hermaphrodite. In diœcious plants, one sex is in one individual, while the opposite sex is in another. It has become a custom to call the plant carrying the male sex, a male plant; and the female sex, a female plant. We have, for example, a male *papaya* (*Carica papaya* L.) tree and a female *papaya* tree. If a plant carries both sexes and if one sex is not functional or functions at a different time than the other, it is, for all practical purpose, a one-sexed individual. We find an example of the first case in *papaya* also, and of the second in *Musa textiles*. (*b*) In the monœcious group both sexes are in the same individual but in different parts of the plant. Corn and cucumbers are good examples of monœcious plants. (*c*) When a plant possesses both the male and female sex organs in the same flower and when both sexes are functional, it is said to be hermaphroditic plant or to be a hermaphrodite. Many of the cultivated crops belong to this group.

Besides a knowledge of the groups described above, a hybridizer must know a number of other points about the flower. These are: (1) Structure, (2) relative time of maturity of stamens and pistils, (3) the quantity of pollen necessary for a good setting of seeds, (4) the length of time at which the pollen remains viable, (5) the amount of injury the female flower will stand, (6) whether the flower is self-fertilizing exclusively or whether it admits of a certain amount of cross-fertilization, (7) conditions of the pistil when fully ripe or receptive of pollen, (8) approximate length of time from pollination to fertilization, (9) the relative position of male and female flowers in the same tree, or of the male and female parts in the same flower (whether the anther is above the pistil so that the pollen drops naturally upon the stigma or whether it is below, necessitating some pollinating agent), (10) the number

of anthers, (11) manner and time of dehiscence of pollen, etc. Some of these points may be learned before starting hybridizing work, while others are found out only through experience.

It should be emphasized that, in careful hybridization work, the essential thing is to control parentage absolutely. Hybridization may be further explained by giving specific procedure with different groups of plants.

With diœcious plants, there is selected one plant for female and one for male. Certain buds of these plants are selected and bagged. It is preferable that these buds should be of the same age. The reason for bagging the buds is to protect them from foreign pollen. For most accurate work, it is always necessary to bag the male flowers as there is always the chance of insects visiting the flowers after they have been on other flowers. This is not imagination ; in very careful bagging work contamination of pollen has been known. With monœcious plants the male and female clusters are bagged separately.

With perfect flowers, that is, with hermaphroditic flowers, the procedure is somewhat different. Here, emasculation, that is, the removal of male parts to render the flower essentially female, is practised. Emasculation must be done some time before the pollen matures, that is, during the bud stage. After deciding on the parent plants that are to be used, a few buds are picked out on the female plant. All other buds and flowers likely to be included by the bag are removed. Even a single bud left in the same bag with the emasculated flower may spoil the work, as the pollen from the non-emasculated flower is almost sure to come out and settle on the stigma of the emasculated one. With a pair of small forceps, the floral envelope is cut off on one side. In some cases the top portion may be cut off or even the whole perianth may be removed without causing injury to the flower. In fact, it is advisable in some cases to remove the whole corolla. However, some flowers are so sensitive that any great injury done them will prevent the setting of seeds. Experience alone will tell what flowers are thus sensitive and what flowers are not. After cutting the floral envelop either in part or in whole, the forceps are thrust into the flower

and *every single anther is removed. Every single anther must be removed* for, if any anther is left, it will produce pollen, a condition to be avoided. It is not advisable in this process of removal of anthers to hold the anthers themselves, for in doing so there is always a possibility of breaking the pollen sac, and when this takes place, some pollen grains may drop and later mature. As soon as all anthers are removed, there remains essentially a female flower, but at this stage, it is not yet ready for pollination. So it is bagged and left for three or four days, even a week, for the stigma to develop to the proper age. The flower is tagged. On the tag some symbols are written which will show the date of emasculation and what treatment is to be given, and about when it will receive this treatment. The tag may include with what parent plant it will have to be crossed. For bags there are used small bags which will remain waterproof for several days.

At the same time that the female flower is bagged the male plant is selected and some buds are bagged without previous emasculation. As with the female flower all other flowers are removed as these may have some foreign pollen brought to them.

The length of time from pollination to fertilization depends on the condition of the bud and the weather conditions. Cloudy days delay pollination while bright days hasten it. At least 24 hours are usually needed.

When the male and female parts are ready for pollination can be told by their colour. They usually become darker, also viscid and sticky due to secretion of different sugar solutions by the cells. When they are ready the male parts are brought to the female; the bag of the female is removed very carefully and the pollen is rubbed on the stigma.

Some plant breeders make it a practice to use a watch glass for holding pollen and a camel's-hair brush for transferring pollen from the glass to the stigma. These helps may be all right if only one kind of pollen is to be used; if several kinds are used, the glass and brush may be sterilized by dipping them in alcohol. But the risk lies in the sterilization not always being thorough.

After pollination, the female new pollinated flowers are rebagged and a record is then taken. The flowers are left bagged until danger from contamination is over.

If fertilization takes place can be told from the discoloration of style and stigma. When the stigma has wilted, the bag may be removed and, after this, the rest of the work is simply taking care of the fruit or seeds until they are ready to harvest. If the flowers are of such a nature that there is danger of losing the seeds by bursting, the flowers or ovaries are kept in a kind of a cage.

After harvesting, the seeds are taken good care of in drying and storage.

When these seeds are planted, the resulting plants are the F_1 plants. At the same time the seeds are planted some parent plants are self-pollinated and plants grown from the self-pollinated seeds for comparison. If the offspring of the self-pollinated parents show great variability, the F_1 plants are to be discarded.

It is a good plan to make back crosses of both parents, that is, to use pollen of each and pollinate flowers of the F_1 plants. The bulk of seeds F_2 will come from self-fertilized F_1. Sometimes, plants have flowers which are self-fertile. In other cases artificial pollination is necessary.

Records. Keeping records is so important that some plant breeders spend more time in record keeping than in actual handling of the plants. The following points should be recorded not only on the tag or label left with the plant but also in the record book : Date of emasculation ; the number or designation of the male parent ; and the date of pollination. In the record book should appear, also, a record of the male and female parents and a description of such characters as are involved in the study.

The hybridizer's working outfit. For general purposes the tools herein named are needed. A small good-powered hand lens to use in examination of small floral parts and a small pair of scissors with slightly bent blades about two and one-half centimeters long. For very small flowers, a small pair of surgeon's scissors with blades about one centimeter long is very convenient. Forceps are useful in removing petals and anthers. Small containers for pollen and

some moist chamber for keeping pollen in a moist condition should form part of the outfit. Small-sized merchandise tags and small-sized camel's-hair brushes may be added.

The nature and pollinating habits of the flowers oftentimes determine the special tools to be used. There are flowers such as of the alfalfa, which are bound to be pollinated while handling them. The emasculation of this type of flowers has caused some plant breeders to devise special tools for the process. Information along this line is well given by Oliver (1910) of the United States Department of Agriculture.

The choice of material for bagging entire plants is sometimes a problem to the breeder, and the following suggestions by the Howards (1920) may be useful. They claim that when they got their best results they used cylindrical muslin covers in the Botanical area at Pusa. The covers were on frames consisting of three bamboo rings. For most purposes the cylinders need not exceed a length of 75 centimeters and a diameter of 30 centimeters; the size may be varied according to the object to be bagged. An advantage claimed for this kind of cover is that it allows a greater percentage of setting. The muslin covers are easily washed after use and they last for two seasons. It is said, also, that no cases of cross-fertilization have been detected through their use.

The preservation of the viability of pollen is another problem which is met with when the pollen has to be shipped a long distance, as from one country to another. The viability of grape-fruit and tangelo pollen has been preserved for six weeks after the pollen grains were gathered, permitting them to be sent from Florida to Japan. The method used in this drying was reported by Miss Kellerman (1915) as follows:

> * * * Anthers in dried vacuum glass tubes, i. e., tube filled with 1—2 inches, cotton ½ inch, exhausted to about 0·5 mm. pressure in the presence of sulphuric acid, the tube then sealed. As far as practicable the pollen was kept at a temperature of 10° C. until sealed.

Commercial hybridization. The best example of this work is that of Luther Burbank of California whom some people call a "plant wizard," a name which Burbank, however, regrets being applied to him.

The life and the work of this wonderful worker is described by Hardwood (1919) in a book.

The following quotations from this book will give a very helpful idea of the method with which Burbank has been able to accomplish his very well known work :

Instead of one or two experiments underway at the same time he may have five hundred at once, all requiring constant supervision, many of them extending over a period of perhaps ten years before they come to fruition. Instead of having a few square feet of ground or a few pots under glass, he uses acres of ground, if necessary, in a single test. In place of contenting himself with a half dozen, or even fifty, plants, in making a given test, he uses if necessary a million, all of them pressing forward in a million similar ways toward the same end. And out of the million he saves perhaps in the last sifting but one, and that one the best of all.

* * * He is confined to no one species nor to any one line of combinations. The whole world is his field, and he makes his selections and forms his combinations in absolute disregard of all precedent. The end in view is the point, how to reach it most directly. It may be along so-called scientific lines, it may be in absolutely new and original paths—more likely the latter —but the means are the non-essentials, the end is paramount.

Hardwood quotes the following advice and warning from Burbank :

The plant breeder, before making combinations, should with great care select the individual plants which seem best adapted to his purpose, as by this course many years of experiment and much needless expense will be avoided.

Quoting Hardwood again :

But Mr. Burbank does not recommend any difficult problems for the amateur ; rather, he insists on the very simplest ones to begin with. He places confidence, the confidence which comes from having accomplished something, as the initial essential * * *.

And to this end he urges taking up a single flower to begin with, never a composite one.

When a certain flower * * * has been decided on, the pollen from one of the two that are going to be crossed in order to give birth to a third that, it is hoped, shall be better than either parent, is gathered upon a little saucer or a watch-crystal, taken to the flower which has been chosen as mate, and dusted down upon its stigma. Then this little flower should be isolated from its fellows and guarded carefully. A paper tag should be fastened to it for identification. Mr. Burbank says to watch the bees, and when they are first a-wing upon their day's work, be sure the flowers are ready to be pollinated.

He says it is wholly unnecessary in ordinary plant breeding to attempt to cover the flower with a screen of tissue paper or gauze. This method has been followed by some in the belief that they were thereby preventing insects from coming in and destroying the pollinating, but he holds that, save in some particular cases, the act is not only absurd but absolutely harmful and more than likely to injure the flower by keeping light and air away from it as to frustrate the very end aimed at. If the pollinating has been thorough, nature may safely be left to do the rest.

Great care also should be exercised in saving the seeds of the plants under test. He recommends air-tight glass jars for the purpose. The jars should be kept in some secure place— it is beyond the power of any mind to say how precious these seeds may prove to be.

From the plants that grow from the new seeds only one should be chosen, the very best of all, the one which is the thriftiest, the best bearing, the nearest to the ideal. The seeds from this one plant should be in turn planted, and then from a very few of the very best plants enough plants saved out to insure a somewhat larger crop for the next generation. Then

from this larger generation only the very best one should be saved. Mr. Burbank lays special stress upon this—to save only one and that the very best of all; no matter if there be hundred plants or a thousand, save only the very best * * *.

According to Hardwood, Burbank's success in being able to judge his plant accurately and pick out the best individual from hundreds and thousands depends on his intuition.

For an amateur, Burbank suggests an outfit consisting of a pair of jeweller's forceps or pincers, a jeweller's eyeglass, a small but powerful microscope, a sharp knife, a saucer for holding the pollen, a soft brush for sifting or dusting the pollen from the saucer to the stigma of the plant to be fertilized. It appears that Burbank himself makes use of any or all of these, sometimes those devised by himself, but chiefly he performs hybridization by securing the pollen upon a watch-crystal and placing it upon the stigma with his finger-tips.

(3) Hybridization combined with selection.

After a hybrid population is obtained, the next step in improvement consists in the isolation or selection of the best hybrid individual. A hybrid population may often consist of different genotypes and phenotypes. The selection of the best strains may be made either by natural selection or by artificial selection.

In artificial selection results may more quickly be obtained by using line selection. The test of the progeny of each hybrid parent will show at once which parent produces segregation. If the selection be for homozygous individual with respect to a certain character, any test row showing heterozygosity may be eliminated immediately. From the rows which are saved, a number of plants are to be selfed and guarded to prevent crossing with the other plants. Repeated line tests will ultimately reveal the line desired. In vegetatively propagated crops, if a desirable hybrid plant is once obtained, "fixation" of desirable characters is accomplished immediately as it is only necessary to propagate the plant by cuttings, buds or other vegetative parts. Segregation is, at once, prevented this way.

The selection of desirable lines in a population may be left to nature. An example of this practice is found in the work of the

Svalof Station. In Newman's (1912) book, we read: "Still another course of procedure in crossing work, especially with autumn wheat, has begun to be practised at Svalof, viz., *the creating of populations.* Two known sorts are crossed and the whole progeny from all second and succeeding generations is sown together *en masse.* The object of this plan is to allow the severe conditions of winter and early spring to either destroy or expose the weakness of as many of the more delicate combinations as possible. In the latter case the breeder is given an opportunity of assisting nature in her work of elimination by practising a form of mass selection. While there is thus effected in a very simple manner, a gradual weeding out of a great mass of unfit combinations, the progeny of a crossing at the time gradually assumes the character of an ordinary mixed population, the different combinations becoming automatically constant as time passes."

What may be hybridized. This is a question that always assails the curiosity of would-be plant breeders. The tendency of amateur hybridists is to attempt crossing widely related forms. Will mango cross with the lanzon and what kind of a looking fruit will be obtained from the work is the type of question quite often asked. Compatibility between two individual plants is indicated, it would seem, by their systematic position. Crosses between families are unknown. Between genera there are only a few cases. We have the teosinte-maize cross. Several foreign cases of this are known. We have a case of a natural cross between these two plants in the College of Agriculture. In 1918 one-half of a trial plot in this College was planted to teosinte and the other half to maize, *Zea Mays indurata* Stur. The corn variety was Blanco Quarentano introduced into the College through Doctor Weston, of the United States Department of Agriculture. Seeds were harvested from the maize culture and planted. Out of 43 plants produced, 40 were somewhat intermediate in appearance between corn and teosinte. The other three plants looked like normal corn plants, except that they did not produce any ear. Likewise from teosinte seeds, hybrids were produced. Teosinte's specific name is *Euchlæna mexicana* Schrad. Collins and Kempton (1920)

reported that in Mexico both teosinte and maize frequently show contamination. They also reported an artificial cross which they made between Florida teosinte and the Tom Thumb pop corn. Another example of inter-generic cross is a hybrid between radish (*Raphanus sativus* L.) and cabbage (*Brassica oleracea* L.). Gravatt (1914) who reported the case declared that the radish was characterized by a great amount of vigour which was evident from the illustration. However, the hybrid was absolutely sterile.

In species hybrids, a very much greater number of cases are found than in inter-generic crosses. Collins (1917) crossed *Zea ramosa* and *Zea tunicata* and found that these species behave in a Mendelian fashion.

In 1908, Wester (1915) crossed sugar apple (*Annona squamosa*) and cherimoya (*Annona cherimolia*). It is said that the hybrid plants " greatly surpass the parents in vigour, and are very similar in habit, stems, leaves, and flowers to the cherimoya."

Babcock and Clausen (1918) cite crosses between *Antirrhinum molle* and *A. majus ; Nicotiana alata* and *N. langsdorffii ; N. alata* and *N. sanderæ ; N. langsdorffii* and *N. sanderæ ; N. rustica* and *N. paniculata ; N. paniculata* and *N. langsdorffii ; N. suaveolens* and *N. macrophylla ; N. sylvestris* and *N. tabacum ; Digitalis purpurea* and *D. lutea* and between *Oenothera biennis* and *O. muricata.* It is declared that while many of the first generation hybrids in species crosses are more vigorous than either parent, others are exceedingly weak.

Commercialization of improved seeds.

The method of introduction of an improved sort of seeds into general agriculture is something that demands serious study and consideration on the part of plant-breeding students. The value of improved seeds lasts as long as their purity is maintained. Once this is impaired, once contamination by inferior material takes place, a gradual " running out " or diminution of its value may be expected.

Experience in the United States has shown that ordinary farmers cannot very well be relied upon to multiply and guard

selected seeds from contamination or other unfavourable effects. Hence, the Government does most of the multiplication work. When the United States Department of Agriculture has a newly introduced variety for trial, it is generally sent to different state experiment stations or agricultural colleges where it is tested and, if found desirable, multiplied, or sub-tested if necessary, in different counties and introduced into general farming. When farmers have to do the multiplication work, it appears that it is necessary to establish a system of supervision and inspection under which technical men can see that the work is done properly. Where the farmers have had training in technical agriculture, such as those who are graduates of agricultural colleges or who have taken short courses in these institutions, the supervision system is not always necessary.

Probably an ideal agency for the commercialization of improved seeds consists in a seed growers' association which may be placed in charge of the commercialization of the improved seeds that the Government isolates. In this association the members are either plant breeders themselves, or those who understand the principles of technical breeding. Each member has a plot in which he grows his seeds. He himself sees that impurities do not enter into the material from planting to the time it is sold. The association certifies to the purity of the seeds when these are sent to the market. This method is similar to that followed successfully in Canada by the Canadian Seed Growers' Associations and in Europe by the Swedish Seed Associations. These associations are subsidized by their respective governments.

The Tropics have not yet reached the stage when seed growing is a common business and when the seed growers are particular about their seeds. Undoubtedly, the time will come when as a result of agricultural evolution, the method found so successful in Europe and the United States will be adopted in the Tropics.

Meanwhile, improved seeds are generally distributed in small amounts direct to the common farmers who are left to multiply them, the Government purchasing the greater part of the harvest for another and wider distribution. In the Philippines especially,

this has to be done in response to insistent public demand for proofs of what the Government accomplishes in the way of agricultural improvement. Such a procedure is unscientific and wasteful; for the seeds soon become impure before they could benefit a greater number of growers. The Government, perforce, allows the people to profit from the results of technical work rather prematurely. It is believed that, in the long run, better results would be obtained and economy effected, if the seed institutions of the Government were made to handle improved seeds until sufficient amount was available for a very much greater and more general distribution. This should be done until the work is taken up by some seed association that can handle it properly.

The following account by the Howards (1912) of a system of seed distribution to cultivators in India is of interest:

Among the successful schemes of seed distribution in Madras the replacement of the mixed crop by a pure Karungani cotton in the Tinnevelly District is a notable achievement. This variety, originally found in a pure cotton tract, was tested on the Koilpatti Farm and proved to be a great advance on the local mixture. A system of seed distribution was then gradually built up, and, at the present time, after five years' work, there are 80,000 acres of this cotton in the district. The agricultural farm grows sufficient cotton to supply the contract seed growers and buys the unginned seed from these men, gins it and arranges the distribution of the seed to the village depôts before the sowing season. Each depôt supplies two or three villages and a suitable man is selected as the depôt keeper who retails the seed under departmental supervision at a fixed rate and on a commission of annas four per bag. The village is regarded as the unit and every effort is made to get all the growers in each village to take up the seed. It is important to notice that the procedure follows that of the best seed growers in Europe and that the seed grown by the contractors is under strict control and comes back to the department every year.

In the Central Provinces, equally striking examples are furnished by the Agricultural Department. In the cotton tracts the work of seed distribution is confined to two suitable kinds, and a fairly large supply of seed is produced on the Government farms which is distributed to private seed growers who themselves retail their seed to the cultivators. In the wheat-growing tracts of this province, the efforts of the department are concerned with distributing pure soft white wheat to selected *malguzars* who are members of the District Agricultural Associations. Each man agrees to sow a large area and to provide suitable arrangements for storing the seed and threshing the crop. In this way it is expected that beginning from a central farm a gradually increasing area of the wheat tract will be sown with one wheat only to the great advantage of the growers and the trade.

The main features of the above examples are that seed distribution starts from a central farm and gradually spreads outwards. The assistance of the best farmers is enlisted, the seed is fully charged for and the work is conducted in tracts where markets already exist for the produce.

NEPS IN COTTON FABRICS AND THEIR RESISTANCE TO DYEING AND PRINTING.*

BY

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INTRODUCTION.

THE occasional occurrence in cotton fabrics of hairs which resist dye and remain white has been known for some time. As early as 1848, attention was called to it by M. Daniel Koechlin-Schouch[1] of Mulhouse, and he suggested that unripe cotton was responsible for the defect. The question was investigated by Crum,[2] and at a more recent period Haller[3] and Herzog[4] have made contributions to our knowledge of the subject.

Crum found the undyed portions of the cloth to consist of hairs with remarkably thin and transparent blades, readily distinguishable from ordinary cotton by their perfect flatness and by their uniformly great transparency. The ribbon width was seen to be greater than that of normal hairs and to show numerous longitudinal and transverse folds. Searching among the motes rejected by the "picking machine," he found what appeared to be the same type of hair, in the form of small matted tufts of silky lustre, several of which enclosed the fragment of a seed or, occasionally, an imperfect seed. Crum noticed that small tufts did sometimes pass

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* Reprinted from *Jour. Tex. Inst.*, XIV, No. 5.

[1] Crookes. A *Practical Handbook of Dyeing and Calico-Printing*, 1874.

[2] Crum. *Proc. Phil. Soc., Glasgow*, 1843, **1**, 98; 1849, **3**, 61; *Jour. Chem. Soc.*, 1863, **16**, 1, 404.

[3] Haller. *Chem. Zeit.*, 1908, **32**, 838-839.

[4] Herzog. *Chem. Zeit.*, 1914, **38**, 1089–1097.

the sifting process of the "picking" machine, ultimately appearing in the cloth as minute lumps or knots, and showing white in the dyed fabric. An examination of specimen of dried bolls enabled Crum to trace the real nature of the thin-walled hairs and to make the following observations :—

1. The contents of capsules unopened and slightly opened consisted of thin-walled hairs* or, as Crum called them, dead cotton fibres.

2. In more fully-developed capsules, the ordinary cotton appeared where it had pushed its way out. Seeds nearer the calyx in the same loculus were clothed with the solid mass, chiefly consisting of the glassy, though transparent, hairs.

3. The glassy hairs frequently appeared in pods of ripe cotton in discoloured spots, manifesting signs of injury before maturity.

4. Small portions of dead cotton were seen, though rarely, in the outer part of the wall of well-clothed and ripe cotton seeds.

5. Small glazed tufts in cotton bales, appearing to have separated from the stem through which they derived nourishment, were of frequent occurrence.

Crum pointed out that a distinct gradation is perceptible under the microscope in different specimens, ranging from dead to normal. He stated that the glassy hairs correspond with the cellular membrane, which was described by the earlier botanists as a primary formation in young plants, possessing a considerable degree of toughness and a certain amount of elasticity, having no perceptible orifices, and yet readily permeable by water.

The dead cotton was observed principally in styles employing indigo, chrome-orange, aniline-violet fixed with tannin, or aluminium and iron mordants, where the dyes were attached to the cloth by deposition from basic solutions of their salts. By this method of fixing, with iron and alumina, white spots appeared which, so Crum believed, would not have been discernible if ordinary mordants had been employed. On examining fabric dyed with a safflower-pink, however, Crum observed that the dead cotton seemed to have

* From the botanical point of view the term "cotton hair" is preferable to "cotton fibre."

attracted its full proportion of dye and the same was the case with Prussian-blue produced from stannate of iron. By repeated dips in the indigo vat, the dead cotton was concealed if not otherwise dyed.

Haller agrees with Crum that the occasional hairs which do not take the dyestuff are really unripe cotton, as the following summary of his observations indicates. Under the microscope, the lumen of this type of hair is seen to contain a considerable quantity of matter, and the hairs do not appear to be convoluted so much. When treated with "cuprammonium" the hairs swell up, but do not go into solution. On treating a mixture of ripe and unripe hairs with a solution of iodine in zinc chloride, the unripe hairs quickly develop a blue colour which appears much more slowly with the ripe hairs. A solution of iodine in potassium iodide colours the ripe hairs a dark brown, unripe hairs acquiring only a light yellow colour. In 18 per cent. sodium hydroxide solution, the unripe hairs retain their convolutions, and only become lighter and more transparent. On dyeing with direct dyes the unripe hairs acquire the deeper colour. Treated with tannin-antimony mordant and dyed with basic dyestuffs, unripe hairs are only dyed in the interior, whilst ripe hairs dye homogeneously.

Herzog states that the dead hairs, which are encountered especially in cotton yarns of poor quality, acquire a considerably lower depth of colour on dyeing in the fabric than fully ripe hairs. This he considers to be an optical effect which is connected with the striking difference in dispersion of the two types of hairs. The thickness of the wall of dead hairs is only $0{\cdot}5\mu$, and if a section of this order of thickness is cut from a thick-walled, fully ripe hair, no deeper colour is apparent, showing that the depth of the colour is conditioned by the thickness of the wall. If several thin pale blue glass plates are piled together to the height of 1 cm., they will appear less deeply coloured than a single plate 1 cm. thick made of the same glass.

Herzog attempts to distinguish between dead and unripe hairs by their behaviour in cuprammonium solutions, and by their appearance under polarised light. He states that unripe hairs

have a rich protoplasmic residue in the lumen which enables them to absorb substantive dyestuffs more readily than normal hairs. Dead hairs are considered to possess no appreciable cell contents.

Examination of faults submitted.

Certain goods from the Calico Printers' Federation, dyed alizarin style, exhibited defects consisting in the appearance of lighter motes showing up on the dyed background, and in a streaky effect due to irregular variations in the shade of the dyed background. The opinion of the calico printers who submitted the goods was that the white motes are due to "neps," i.e., clusters of short folded immature hairs which failed to absorb either the dye or the mordant or both. They believed that the streaky effect is due to some inferior quality in the cloth receiving its maximum expression in the motes, and stated that the fault is most prevalent in goods dyed with alizarins, para-red and indigo.

The results of examination of the fault will be dealt with under the following headings—(*a*) The motes, (*b*) the streaks, and (*c*) the grey cloth.

The motes. The defects due to motes are of the following main types :—

1. A nep which is only loosely incorporated in the yarn becomes detached after printing, leaving a white area below.
2. A loose end of yarn becomes detached or moved to one side after printing and exposes a white patch below.
3. Small white specks involving a large number of hairs, all of which proved to be dyed normally at other portions of their length. The specks of this type are confined to a single strand of yarn, thus eliminating roller damage as a factor in its causation. More than one type could be distinguished. In some cases the white spot was so far below the general level of the fabric that it could not have been affected by the printing roller. In other cases the mote occurred at the general level of the fabric, and was possibly

protected from the action of the dye by a particle of foreign matter.

4. Neps *in situ* causing lighter spots are by far the most common type of defect. Under a low-power binocular microscope they were seen to consist of a matted tangle of hairs, a few of which showed the rich development of colour characteristic of normal hairs. When dissected, the nep was resolved into a mass of lightly-dyed or undyed thin-walled hairs which, in the aggregate, however, was intensely coloured. The individual hairs were separated from each other with difficulty, and sometimes crumbled to fine particles at the slightest touch of the needle.

When a whole nep was mounted in Canada-balsam, a substance of refractive index similar to cotton, the general shade of colour was not materially different from that exhibited by normal parts of the fabric. This suggested that much of the apparent difference in colour in hand specimens is purely optical, and due, as Herzog suggested, to dispersion effects. It is worthy of note that the surface neps exhibit a high degree of glaze, imparted, no doubt, by the calendering process, and thus reflect more light than the ordinary dyed yarn. Experimental dyeing of the grey cloth with Congo-red failed to reveal any marked differences in shade, but on treatment with a hot iron in a damp condition to imitate the calendering process the neps became glazed and immediately showed up as typical light patches. In fabrics dyed with para-red, however, the motes were prominent in uncalendered goods, and the intensifying effect of calendering is, therefore, not universal.

The streaks. A defect in dyeing is often shown in the presence of light streaks confined to a single strand of yarn, extending in some cases to a length of 6 mm. or more. When the cloth is held up to the light the streaks are dark, rather than light, and this is also the case in specimens cleared in clove oil and mounted in balsam. Under the microscope, the same matted tangle of thin-walled, fragile hairs was seen, with a few strongly dyed normal hairs running ridge-like across the semi-glazed surface. The streaks may thus be regarded

as elongated neps. When dissected, the tangled mass resolved itself into a mixture of unthickened and partially thickened hairs, together with broken tips of hairs. On the whole, the elongated neps were essentially the same in structure as the surface neps previously described.

A point of some importance, however, requires emphasis. Although most of the hairs in neps were undoubtedly weakly dyed, there were isolated patches of the debris in which colour could not be seen. In spite of the difficulty of manipulation, small portions of such hairs were treated with sodium hydroxide of the usual mercerizing concentration, and measurements were made which showed that no shrinkage had taken place ; it is therefore clear that associated with the tangle of thin-walled hairs was a matrix of hair debris with practically no secondary thickening. This debris exhibits dispersion effects to a high degree, particularly when glazed, but, on account of the absence of dye, becomes almost invisible in mounting media of approximately the same refractive index.

A comparatively uncommon type of streak consisted of a group of hairs which were not so thin-walled as to form neps in the spinning process, but which were too thin-walled to exhibit the full development of colour. There was only a slight difference in colour from the rest of the background.

The grey cloth. A sample of the grey cloth before dyeing was examined, with the following results :—

1. Tufts of thin-walled hairs, exhibiting parallelism, could be readily recognized by their semi-glassy appearance. Dyeing of these portions would result in a localized slight diminution of the full shade of colour.
2. Neps consisting of thin-walled hairs in a matted and tangled condition were abundant. Most of these were yellow in colour.
3. Seed coat particles were abundant, and often formed the nucleus of neps.

Tufts of thin-walled hairs, similar to those described under (1) above, are a common feature of normal seeds, and are to be

ascribed to unfavourable conditions of nutrition during growth, a question which will receive fuller discussion later.

Yellowness of thin-walled hairs is invariably a consequence of attack by insect or cryptogamic parasites during boll development.

A large amount of thin-walled, yellow-stained cotton occurs in West Indian, Sea Island cotton through this cause, and is baled and shipped specially as stained cotton.

Effect of mercerization on the colour of the neps.

An indigo-dyed fabric in which the neps were of conspicuously lighter shade than the background was compared with similarly dyed cloth which had previously been mercerized. The general result of mercerizing was to render the defect much less obvious. This fact is apparently well-known to the trade, and has its explanation in the change of geometrical conformation of a mercerized hair. The flattened ribbon, characteristic of a thin-walled hair possessing an appreciable amount of secondary thickening, is converted on mercerizing into a form in which the area of cross section tends to be circular and in which dispersion effects are minimized. The wall thickness is considerably increased and a greater capacity for taking the dye results. The primary wall debris containing no cellulose is not affected by mercerizing and thus the defect is still visible to some extent.

Summary of observations and conclusions on the fault.

1. The presence of motes and streaks of a lighter shade than the dyed background is mostly due to the presence of neps.

2. The neps consist of a matted tangle of thin-walled hairs which, in surface view, exhibit a glazed appearance.

3. The thin-walled hairs are essentially of the type described by Crum as " dead cotton."

4. Herzog's view that the difference in shade is purely an optical effect is substantiated on two main grounds: (*a*) Elimination of dispersion effects by immersion in various mounting media

renders the difference in shade in dyed hairs practically negligible; and (*b*) in experimentally dyed cloth, the motes and streaks only appeared when the glazed surface of the neps was produced with a hot iron.

The cell-wall thickness of cotton hairs.

Since the main cause of the differences in shade of the dyed background of the fabric has been established to be due to thin-walled hairs, i.e., to unequal distribution of wall thickness in the hairs composing the yarn, it is advisable to discuss the question of wall thickness in some detail, more particularly with reference to the causes of variations in magnitude and mode of distribution of this character.

Balls[1] points out that if, for any reason, the cell-wall of the hair consists mainly or entirely of primary wall with little or no secondary thickening, there will be little resistance to bending stresses. Consequently, such flabby hairs will be easily rolled into a tangled nep or coil. Such hairs are more likely to occur in fine cottons which have normally a thin secondary wall. Some environments produce more than others, as also do some varieties; thus West Indian, Sea Island cottons are bad in this respect, whilst Sakellaridis Egyptian cotton is inferior to the varieties which it has replaced, and the now extinct Yannovitch cotton was remarkably free from nep. Since one of the causes of flabby hairs is genetic, it is clear that the recognition and elimination of strains possessing an abnormal amount is one of the most promising methods of reducing nep.

Production of neps during manufacture.

Given the presence of hairs with thin walls, there are many opportunities during manufacture which are likely to produce neps by their differential reaction to bending stresses. Among the recognized causes of neps are the following :—

In ginning.—Faulty ginning.

In scutching.—(*a*) Excessive beating; (*b*) beater blades out of order; (*c*) trying to get too much cotton through one machine.

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[1] Balls. *Handbook of Spinning Tests for Cotton Growers*, London, 1920.

In carding.—(*a*) Carding too heavily; (*b*) neglecting stripping and grinding; (*c*) bad setting of flats, rollers and clearers, doffer and doffer combs; (*d*) allowing the web to become broken and to fill up all space between the doffer and the calender roller, until the cotton is carried over the doffer and fills up the doffer comb, so that a portion of the hairs remains subject to the action of the comb for some time; (*e*) overloading the wire.

The botanical aspect.

From the point of view of the botanist, there are two sets of factors influencing the cell-wall thickness of cotton hairs; these are respectively environmental and genetic.

The influence of the environment on cell-wall thickness. In the first place, it is beyond dispute that each individual cotton plant possesses a certain association of genetic or hereditary factors which, under constant environmental conditions, are capable of manifesting themselves in the production of hairs of a definite length and wall thickness. Environmental conditions, however, can never be equal in their effect on all parts of the plant. For purposes of discussion, they may be divided into two main classes, external and internal.

The external environment includes within its scope soil conditions, water supply, temperature, humidity, density of population, air movements, illumination, etc. A change in the general environmental complex will, in some way, be reflected in mean cell-wall thickness, and in support of this statement may be adduced the well-known seasonal variations in the quality of the cotton crop from year to year, grown from the same seed. Thus, when seed of Superfine St. Vincent cotton was grown in a region of little rainfall the wall thickness apparently increased *pari passu* with the environmental aridity, but when grown in the humid greenhouse of the Shirley Institute, the wall thickness was reduced so that the cotton was virtually of the same magnitude as that characterizing "dead cotton."

The internal environmental effect is chiefly positional. There is competition for nutrients from boll to boll, from seed to seed in the

boll, and from hair to hair upon the seed. In examining cross sections of hair from the same seed, it is not unusual to find patches of one to two hundred hairs closely grouped together, characterized by thin cell-walls. It is clear that proximity to the nutritive channels plays an important part in the determination of wall thickness. Patches such as this not infrequently pass through to the finished yarn, as was noted in the discussion on the fault described in this paper. The differences in the position of bolls on the plant would make itself felt as an influence upon wall thickness even if they were all at the same stage of maturity at the same time. This is not so, however, and in practice the later bolls on the plant usually mature at a time when, by reason of senescence or attack by cryptogamic parasites, the leaf area of the plant capable of photosynthetic activity has been considerably reduced. Not to be forgotten, also, is the effect of reproduction in photosynthetic activity due to defoliation by leaf-eating caterpillars, which in some cotton-growing districts may take place at almost any period of the growing season. It will be seen that distribution of wall thickness of hairs in a given bale is necessarily patchy. Uniform environment on the seed coat does not involve more than a limited area, and elimination of positional effect can only take place in hairs which are adjacent on the same seed.

The influence of competition from seed to seed in the same boll may, in extreme cases, result in the death of half-grown seeds, which are clothed with hairs of little or no secondary thickening. Examination of a large number of bolls both of Upland and Sea Island cottons shows this phenomenon to be of frequent occurrence, so much so that probably most of the flabby hairs in undiseased cotton is due to this cause.

The influence of genetic factors on cell-wall thickness. It is probable that the death of some of the partially developed seeds in the boll is due to gametic incompatibility, i.e., the combination of male and female elements which have united to form that particular seed is non-viable after a certain age. Some varieties differ constantly in the percentage of non-viable seed, and the basis of this can only be genetic.

Death of seed through attack by insect or cryptogamic parasites. It has been mentioned above that the death of seeds either through competition or for genetic reasons is a fruitful source of flabby hairs. Death of seeds may also be caused by boll-puncturing insects, chiefly types of plant bug, carrying various forms of fungoid infection. In this case, the seed may be drawn upon by the insect for its food supply and ultimately killed, or a general growth of micro-organisms may additionally supervene and involve the whole boll in decomposition and disorganization. Certain boll diseases may attack the external wall of the boll, and, by progressive penetration, destroy more or less of the boll contents.

Whatever the cause of the death of a seed in a half-matured condition, the hairs on that seed are invariably excessively thin-walled and weak, and are likely to initiate neps in the spinning process. The yellow colour, whether due to insect puncture or disease, is strongly characteristic, and such cotton may be suspected as the source of some at least of the neps in neppy cloth.

General considerations.

It is clear from what has been said above that the existence of thin-walled or flabby hairs in a sample of cotton is due to a variety of causes, some of which are partially avoidable and others inevitable. The consumer of cotton is at present helpless in the hands of the agriculturalist. His most urgent requirement is uniform cotton, and in regard to the present problem of thin-walled cotton, the position may be summed up by saying that the variability of the wall thickness should be reduced to a minimum. Those engaged in cotton breeding are urged to take up the study of means of eliminating strains characterized by thin-walled cotton, and to investigate the physiological and genetic factors conditioning its appearance. From the point of view of the spinner, the recognition of raw cotton containing abnormal amounts of thin-walled hairs is important, and a method is under consideration whereby it is hoped to establish definite standards for wall thickness in varying types of cotton, and in conjunction with this to obtain an idea of the number of thin-walled hairs normally present.

Summary.

1. The work of Crum, Haller, and Herzog is summarized.

2. The results of microscopic examination of an alizarin-dyed fabric which showed motes and streaks are presented. The conclusion is drawn that the defect is one essentially similar to that described by Crum, and is attributable to neps composed of thin-walled hairs. The difference in colour of the neps is considered to be mostly optical in nature, for reasons which are given, but the nep aggregate apparently contains debris of hairs consisting of primary wall only, which are glassy in appearance and remain undyed.

3. The effect of mercerization on the difference in colour shown by neps in an indigo-dyed fabric is to render such difference less conspicuous. This is considered to be due to alteration in the shape of the cross section, reducing dispersion effects, and to an increase in the wall thickness, which causes an increased capacity for dye.

4. The cell-wall thickness of cotton hairs is considered in detail and reference is made to recognized causes of neps during manufacture.

5. The effect of environmental and genetic factors on cell-wall thickness is shown to be complex, and it is concluded that much of the thin-walled cotton arises through death of seeds before maturity, either through competition, genetic factors, or attack by parasites.

6. Elimination by genetic methods of strains characterized by excessive amounts of thin-walled cotton is suggested to the cotton breeder, as well as a detailed study of the physiological and genetic factors influencing its amount.

Notes

OIL CONTENT OF CASTOR SEEDS AS AFFECTED BY CLIMATE AND OTHER CONDITIONS.

EXPERIMENTS with castor seeds were first initiated at Sabour by Mr. C. Somers Taylor, Agricultural Chemist to the Government of Bihar and Orissa. In the first series, the results of which have already been published by him (*Pusa Bull.* 117, 1921), attempts were made to determine whether by chemical selection it was possible to improve the race of castor as regards its oil-yielding properties. It was, however, found that although seeds collected at random gave widely varying oil-content—from as low as 21·8 per cent. to as high as 50·8 per cent. on the seed—this character was not transmitted, when grown under similar conditions, even for one generation; their progeny giving almost in every case a mean oil-content of about 49 per cent. in healthy seeds. The *bhadoi* (monsoon) crop, which was generally well developed that year, gave a better oil-yield than the same variety grown as *rabi* (winter) crop. It was then thought possible that weather and other conditions might exert some influence on the oil-yielding properties. Selected seeds, having an oil-content of 50 per cent. or above, were distributed for growth to the different farms where different conditions might prevail. Samples of the crop grown from these seeds were obtained from Cuttack, Dumraon, Sambalpur and Sepaya, but with the exception of the last of which the *bhadoi* crop gave a lower oil-content (43·3 per cent.), all others maintained their oil-yield. Many of the kernels of the samples of the *bhadoi* castor grown at Sepaya were found to be in a shrunken condition indicative of unhealthy growth. Again the Pachka castor grown on the Sabour farm, both as *bhadoi* and *rabi* crop, gave the same oil-content in each case (51·0 and 51·6 per cent. on the whole seed). The climate therefore does not seem to exert any appreciable

influence on the oil-yielding properties of the crop, except so far as it affects proper development of the seeds.

Different manurial treatments also do not seem to have any effect on the oil-content of the seeds. Lines were laid down at Sabour to receive separately potassium sulphate, superphosphate, and ammonium sulphate, as well as a mixture of these three and cowdung and *basti* ash, i.e., ash of the village refuse. The seeds used were from the same parent. The application of the manures resulted in a considerable increase in the yield of seeds but the percentage of oil in the seeds remained singularly constant. The following table will make this clear :—

	Control	Pot. sulph.	Super.	Ammon sulph.	Mixture	*Basti* ash	Cowdung
Yield of seed in lb. wt. ..	6·44	13·19	11·06	12·50	13·19	10·41	14·16
Percentage of oil in seeds ..	51·35	52·05	51·50	51·75	51·27	51·80	51·70

Attempts were also made to find if the amount of space left between the plants had anything to do with better development of seeds and consequent higher production of oil. Bulk seeds, originally from a single plant, were sown, allowing different spaces between the plants and also from line to line, but no considerable effect was perceptible in respect either of the total yield or of the oil-content of the seeds. On the other hand, the wider space allowed the plants to produce more branches, each of which produced heads which took its own time to mature and consequently they could not be harvested all at the same time. Plants in which 2 feet spacing was allowed from line to line and 1 foot 6 inches to 2 feet from plant to plant produced only one long head and were therefore more convenient to harvest.

It was found that the seeds on the oldest head of a plant gave an average result of 50·7 per cent. oil, while those on the youngest and therefore less mature head from the same plant gave 47·8 per cent. oil. The amount of oil present in individual seeds seems to depend therefore not directly on climate or on manurial treatment, but on the degree of maturity of the seed.

The method of harvesting adopted by the cultivator in Bihar is to remove the head, of which only a few of the top seeds have ripened, the rest of the seeds attaining maturity slowly after keeping. A trial was made to find out whether this method would give seeds of the same oil-content as those obtained by removing matured capsules only. Several plots were laid out, each plot being sown with seeds which originally came from the same parent plant. The result is indicated in the following table :—

Percentage of oil on the whole seed.

Plot No.	Removing matured capsules only	Harvesting in cultivators' method	Difference in favour of the former method of harvest
2	52·9	52·7	0·2
3	53·4	51·0	2·4
5	48·3	48·3	nil
6	49·9	49·7	0·2
11	51·1	51·3	—0·2
12	48·6	49·0	—0·4
7	50·2	47·2	3·0
8	49·7	46·0	3·7
14	49·5	49·8	—0·3
16	51·0	48·6	2·4
17	47·3	47·3	nil

Thus, against three cases out of eleven where there was a very slight difference in favour of harvesting whole heads, there are four where the removal of matured capsules gave a considerably larger percentage of oil. Although after the removal of the whole heads, the seeds were kept apart for several weeks in order to allow them to ripen, the degree of maturity was not the same in all cases, and even the slight difference in maturity in different seeds from the same head seemed to have a considerable effect. This therefore strengthens the conclusion that the oil-content of castor seeds

depends more upon the degree of maturity than on anything else. The Bihar cultivators' method of harvesting does not ensure that the seeds will have their maximum oil-content and cases may arise in which the average oil-content may fall short by over $3\frac{1}{2}$ per cent. of what can be obtained by harvesting them when all are fully ripe.

It is clear that for purposes of analysis with a view to the selection of superior oil-yielding types, great care should be taken to pick individual capsules as they mature. [MANMATHA NATH GHOSH.]

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BUD-ROT OF COCONUTS CAUSED BY *PHYTOPHTHORA PALMIVORA*.

DURING 1913-14 inoculation experiments were conducted on young coconut palms with the fungus *Phytophthora palmivora* by Dr. Shaw and myself (*Annales Mycologici*, XII, No. 3, 1914). It was then proved by a number of inoculations that this fungus produces typical bud-rot on young coconut seedlings. Later on it was doubted by Mr. Sharples in one of the papers in the *Annals of Botany* (XXXVI, January 1922, p. 55) whether in mature coconut palms this fungus can cause typical bud-rot. I felt sure from my close knowledge of the parasitic nature of this fungus that it can produce the bud-rot in mature trees as well as in the seedlings.

With a view to confirm my statements, two well-grown healthy trees about 15 years old and with stem measuring about 12 feet in height were selected for the experiment. Diseased specimens of leaves and leaf-sheaths from a bud-rotted coconut tree in Kasargode, South Kanara, were obtained on 15th August, 1922. Fresh masses of mycelium and sporangia were found inside the folds of the diseased leaves. From this material a pure culture was obtained on French bean and oat agar on 18th August, 1922, and subcultures were made from these from time to time.

On 29th November, the two coconut trees selected for the experiment were inoculated with subcultures of 18th September. The fungus material was removed from the culture tube carefully

with a sterile platinum scoop and mixed with a few drops of sterile water. This material was carefully placed inside the shoot of the trees which were wetted with sterile water before inoculation. The outer portion was covered over with a mass of coconut fibre which was kept wet by splashing water over it. Spray of sterile distilled water was given every day to the shoots in which the fungus material was put. Two more trees were treated in this way but without the fungus being put in the central shoot and kept as control. On 11th December, i.e., thirteen days after inoculation, characteristic diseased spots were seen on the leaves where the fungus was put. A week later, the shoots of both the inoculated trees showed signs of yellowing. They were given regular spray of sterile water every day. Ten days after the spot formation was noticed, that is, on 21st December, the shoots rotted and could easily be pulled out from the crown.

Microscopic examination showed the presence of the fungus *Phytophthora palmivora* on the inoculated portions. A bit of the diseased portion was incubated and the same fungus was re-isolated.

At this stage, wetting the crown with the spray of water was discontinued. In the course of two months, the crown of the two trees as a whole were blown over by wind leaving the two trees as bare poles. The controls remained healthy throughout the experiment. This clearly proves that the fungus *Phytophthora palmivora* can produce typical bud-rot on mature trees also. In nature, tall, mature trees are noticed killed by this fungus with the bud completely rotten. [S. SUNDARARAMAN.]

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INDIAN DIPLOMA IN DAIRYING.

THE following press communiqué, dated 13th November, 1923, has been issued by the Government of India (Department of Education, Health and Lands) :—

The Government of India have decided, in connection with the working of the Imperial Institute of Animal Husbandry and Dairying at Bangalore, to institute an Indian Diploma in Dairying on the lines of the British National Diploma in Dairying, to be

granted to persons who have successfully completed a course of not less than two years' instruction at an institute recognized by the Imperial Institute as capable of teaching up to the standard required for such a diploma.

It is hoped that sooner or later Agricultural Colleges in India will possess the necessary staff and equipment and will be willing to train pupils for this diploma, but, for the present, the necessary course of instruction will be commenced on January 1st, 1924, at the Imperial Institute of Animal Husbandry and Dairying, Bangalore, where eight selected pupils will be taken.

The course will last for two years with two months' vacation each year. The holiday period will be the months of April and May.

The course will consist of practical and scientific training in the principles of cattle-breeding, cattle feeding and management, Indian and foreign breeds of dairy cattle, stock judging, diseases of dairy cattle, dairy farm buildings, milk production, handling and sale, butter and *ghi* manufacture, dairy chemistry, dairy bacteriology and dairy farm book-keeping. Ample scope is available for practical and laboratory work at Bangalore. The practical instruction will be under the direction of the Imperial Dairy Expert and the scientific training will be carried out under the control of the Physiological Chemist to the Government of India.

Students must be of good character and over 17 years of age. The minimum educational qualification necessary for admission is the Matriculation or the School Final Examination, but, in special cases, the Imperial Dairy Expert will have power to waive this condition.

A tuition fee of Rs. 15 will be charged from each student for each month or part of a month he is actually in residence at the Institute. Accommodation will be provided free of charge which pupils must avail themselves of. No stipends will be paid to students and travelling expenses must be borne by students themselves.

At the close of the course an examination will be held for those students who have satisfactorily completed the course of instruction, and the Indian Diploma in Dairying will be awarded

by the Imperial Institute of Animal Husbandry and Dairying to successful candidates.

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THE SECOND WORLD'S POULTRY CONGRESS AND EXHIBITION.

THE Second World's Poultry Congress will be held in Barcelona from 10th to 16th May, 1924, under the official patronage of the Spanish Government and of the Municipality of Barcelona, and under the Honorary Presidency of H. R. H. The Prince of Asturias, Honorary President of Spanish Aviculturists. The opening sessions and sectional meetings of the Congress will continue up to 14th May in Barcelona and the closing sessions will be held in Madrid on 16th May. The deliberations of the Congress will include such important topics relating to poultry breeding and industry as: (1) Research and investigation, (2) State-aided and voluntary efforts to develop the poultry industry (inclusive of educational work, (3) Hygiene and disease, and (4) National and international trade in eggs and poultry.

The Exhibition, which will be held simultaneously with the Congress, opens on 10th May and will be installed in the Exhibition Palace at Barcelona. It will remain open for nine days, from 9 a.m. to 6 p.m. each day. The Exhibition will be in the nature of a display, the object being educational and not competitive; and it is intended to represent every branch of poultry industry and commerce therewith.

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CONSUMPTION OF AMMONIUM SULPHATE IN JAVA.

THE American Vice-Counsul Rollin R. Winslow, Batavia, in a report published in the Commerce Reports of the United States Department of Commerce, dated 17th September, 1923, states that considerable amounts of chemical fertilizers are used in Java and that these are admitted duty-free.

Ammonium sulphate is the principal fertilizer used, and of the 70,740 tons imported in 1922, 23,646 tons came from the United States and 35,726 tons from Great Britain. The amount from the United States shows a decided increase over the previous year, principally because of the fact that Germany is being forced to

withdraw from the market. Before the war considerable quantities were imported from Germany, but that country has not regained its place. The Germans are still in the market to a slight extent, but the chaotic conditions there have forced buyers to look elsewhere, particularly because deliveries are uncertain.

There is a wide variation in the amounts of ammonium sulphate used by the different estates in the Netherlands East Indies. Some lands recently reclaimed from the jungle do not require any, while the older estates, where the soil is heavy, use up to 10 piculs to the bouw, or about 800 pounds to the acre. It is claimed that no other artificial fertilizer is so well adapted to the cultivation of sugar.

The sugar estates generally place their orders a year in advance. They require that the ammonium sulphate contain an average of about 20 per cent. nitrogen, and approach a fixed standard of moisture content. Further, it should be free from sodium, and not contain more than 1 per cent. of free sulphuric acid. Packing is usually in bags of 112 to 200 pounds.

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SUGARCANE CULTIVATION IN BARBADOS: INCREASED PROFITS FROM NEW SEEDLINGS.

THE Barbados Agricultural Society have requested the Governor to appoint a Commission to enquire into the working of the local Department of Agriculture to make recommendations for properly equipping it to carry on its work in an up-to-date manner.

That this was not intended as a reflection on the conduct of the department was shown by the fact that the resolution authorizing the request was moved by Mr. John R. Bovell, the Director.

In the course of his remarks on this occasion Mr. Bovell made the striking statement that during the eight years 1913–15 to 1920–22 the growers of sugarcanes in Barbados benefited by the work of the Department of Agriculture, in round numbers, to the extent of something like ten million dollars and the factory owners by an additional sum of ten million dollars as a result of growing the better seedling sugarcanes when compared with the White Transparent.

In support of his contention, Mr. Bovell said that on the average for those eight years the White Transparent yielded 20·45 tons of canes per acre, the B.H.10(12), 29·05 tons, Ba. 6032, 31·76 tons and the Ba. 11569, 26·84 tons of canes per acre per annum respectively. That is, these three canes under the same conditions for the eight years averaged 29·22 tons of canes per acre, while the White Transparent averaged 20·45 tons, an increase of 8·77 tons or 42·9 per cent.

During the eight years the average price at which dark crystal sugar sold was $4·90 per 100 lb. At this price, and at 7 lb. of dark crystal sugar per 100 lb. of sugarcanes, the value of a ton of canes was $7·68, so that the value of 8·77 tons of canes was $67·35 per acre per annum more than the White Transparent.

From this would have to be deducted the extra cost of cutting, loading and carting the better canes, say 72c. per acre, leaving a net gain of $66·63 per annum. It was generally estimated at the present time that about 35,000 acres of canes were reaped annually. Assuming that of this area only 20,000 acres were under the seedling sugarcanes mentioned above, although believed that there were more, the value to the growers would at $66·63 per acre be $1,332,600 per annum or for the eight years $10,660,800.

Proceeding, Mr. Bovell, after dealing with the experience of an estate in the dry district, showed how increased expenditure on the department would be justified by results in such lines of work as, for example, increasing the yield of sugarcanes per acre by growing them from stools containing the average maximum number of canes per stool and by improving the quantity and quality of cotton produced.

The resolution, which was seconded by Dr. Gooding, was carried unanimously. [*The West India Committee Circular* 653.]

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COIMBATORE CANE SEEDLINGS IN ANTIGUA.

A CORRESPONDENT in Antigua writes:—" The North Indian seedling canes—these are doing wonderfully. All of the varieties have germinated well and although the canes were only planted in

the end of April or early May, they are a long way ahead of many plants six months older. Harcourt, the Assistant Director of Agriculture, has taken no end of trouble with them. He sunshaded and watered them at first till they started to grow. You will indeed be pleased when you see them."

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STUDY OF SUGARCANE ROOT-ROT IN JAVA.

Many reports having come to the experiment station for the Java sugar industry that root-rot seemed to occur in sugarcane fields planted in succession with the same variety of cane rather than in fields where one variety was followed by a different variety, an exhaustive investigation was undertaken by Dr. J. H. Coert. The investigation showed that while there was some ground for the current opinion, the reason is not that one particular variety poisons the soil for itself more than another variety. What appears to happen is that the infection of the soil persists for some time after the harvest, and the chance of root-rot depends on the length of time elapsing between harvesting and replanting. From the data it appears with tolerable clearness that the chance of root-rot is greater if the cane planted in succession is a later ripening variety, and less if it is an earlier ripening one, because in the latter case the land remains unoccupied for a longer time.

For the same reason, a three-year rotation gives less occasion for root-rot than a two-year rotation.

It also appeared from the investigation that root-rot is very rarely met with in the red soils (lateritic) of Java.

Of the 9,493 bouws studied, 443, or 4·67 per cent., were affected by the disease ; where the rotation was three-year the percentage was 3·43 ; where the rotation was two-year it was 10·42. [*Facts About Sugar*, XVII, 10.]

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EUROPEAN BEET CROP, 1923-24.

The latest estimates of the beet sowings in Europe and production of sugar in season 1923-24, as compared with the actual

acreage and realized production of the season 1922-23, are as follows :—

Names of countries	1923-24		1922-23	
	Hectares	Tons of sugar raw value	Hectares	Tons of sugar raw value
Germany	343,520	1,190,000	363,789	1,463,000
Czecho-Slovakia ..	219,486	830,000	184,591	726,472
Austria	12,600	40,000	11,563	24,000
Hungary	44,308	110,000	30,020	82,000
Poland	143,000	400,000	110,000	301,890
France	149,848	450,000	127,450	493,000
Holland	73,500	270,000	57,536	255,592
Belgium	72,264	260,000	59,176	268,928
Italy	90,000	310,000	85,321	297,280
Spain	60,000	180,000	48,045	170,000
Denmark	32,000	110,000	23,944	90,000
Sweden	43,700	150,000	16,716	71,800
Russia	230,000	330,000	175,000	200,000
Other countries ..	69,925	180,000	59,745	108,000
	1,584,151	4,810,000	1,352,886	4,551,962
TOTAL IN ACRES ..	3,914,437	..	3,342,981	..

The present estimate thus shows an increase in production of about 258,000 tons in 1923-24 as compared with the last year.

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WORK OF THE IMPERIAL INSTITUTE.

WE have received the following for publication :—

The Imperial Institute for many years has been steadily endeavouring to further the development of the resources of the Empire, particularly with regard to the commercial and industrial utilization of raw materials of all kinds. The best known department of the Institute is its well-arranged Exhibition Galleries, open to the public and schools, in which are displayed the principal raw products and manufactures of the various parts of the Empire, accompanied by descriptive labels and illustrated by maps, diagrams, photographs and models. This is the only permanent exhibition of the kind in the Empire.

Less familiar to most people is the important work of the Scientific and Technical Department, which investigates the new or little-known raw materials of the Empire, and suggests action for

their commercial utilization. The Technical Information Bureau deals with enquiries of the most diverse origin and character connected with the production, utilization and valuation of raw materials. A vast amount of information emanating from the Institute has been disseminated by means of the Institute's Bulletin and other publications, and also through other channels, including the Chambers of Commerce.

An opportunity of becoming better acquainted with the nature of the Institute's activities and the many important results which have accrued from its work is now afforded in a recent issue of the "Bulletin of the Imperial Institute." This publication is devoted to a comprehensive report on the operations of the Imperial Institute carried out by its different Departments and various Technical Advisory Committees.

Further examples of the important work of the Institute are contained in the current issue (No. 2 of 1923) of the same Bulletin.

A full account is given of the lignite deposits of the Southern Provinces of Nigeria, which were discovered during the Mineral Survey carried out under the auspices of the Institute. The deposits exist over a considerable area, some being favourably situated for transport. A detailed study of the lignite in the laboratories of the Institute showed that it was of satisfactory composition and calorific value. It is quite suitable for briquetting, and briquettes used as fuel in firing trials in railway engines and steamboats in Nigeria have proved satisfactory.

Another article summarizes the investigations conducted at the Institute under the Ceylon Rubber Research Scheme. Particulars are given of the results of tests of a large number of specimens, prepared in Ceylon by different methods, with a view to ascertaining the mode of preparation best suited to the needs of the manufacturer.

Other subjects of interest referred to are Indian worm-seed as a source of the drug santonin; a new essential oil obtained from a Western Australian plant; and the results of practical pottery trials with Australian clays. There is also an interesting illustrated

article on the trees of the Gold Coast. The value of a number of Gold Coast and other Colonial timbers is being investigated at the Institute with the advice of a Committee which includes representatives of the timber trades and industries of England.

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INCREASING CONSUMPTION OF NON-AMERICAN COTTON IN LANCASHIRE.

THE use of outside growths of cotton in Lancashire and on the Continent is developing largely, and what is more astonishing is the great demand for dirty cotton. In past years Lancashire spinners would not "look at" such cottons as they are eager to obtain now. There has been a great deal of substituting American cotton by Egyptian owing to the relative cheapness of the latter, but manufacturers hesitate to do so on account of the complaints that are bound to arise when the normal state of affairs returns and American yarns are again used, as it is then that the customers complain of a falling-off in quality of the cloth and trouble begins.

The extent to which outside growths of cotton are being used in England is evident from the takings of American cotton from August 1st to March 16th. England took 22,000 bales less than in the previous year for the same period, but the total of all kinds of cotton taken by Lancashire spinners was 1,828,047 bales against 1,672,767 in the previous year—an increase of 155,280 bales. (*International Cotton Bulletin*, No. 3, 1923.)

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COMPULSORY COTTON STANDARDS IN THE U. S. UNDER THE NEW COTTON STANDARDS ACT.*

COTTON classification is of very great importance to the grower in the United States as well as to the spinner. If the uniform standard be obtained applicable to grower, merchant, distributor

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* Mr. Charles J. Brand held recently meetings with the various Cotton Exchanges in Europe and called at the offices of the International Cotton Federation. This article is the summary of Mr. Brand's arguments in favour of the universal introduction of the American Cotton standards. [A. S. P.]

and spinner alike, economy and better understanding cannot fail to result.

In August 1914, the United States Cotton Futures Act authorized the establishment of standards by which the quality or value of cotton might be judged quoting its grade length of staple, strength of staple colour, and such other qualities, properties and conditions as it might be practicable to determine standards for. The grade standards established under that law were made compulsory in the United States in all transactions involving future contracts on the grade exchanges. These standards, with one slight change, have now been in use for 9 years. More recently permissive length standards have been established, and are being found useful in the arbitration of disputes.

Spinners realize as fully as any manufacturing interest in the world that in every plant the necessity for economy and efficiency is a fundamental consideration. They have standardized their machinery, their processes, their manufacturing practices, their policies of management, and every other conceivable thing. Standardization of product, whether yarn, cloth or otherwise, plays a large part in the magnificent development of the cotton spinning industry of the past 70 years.

Standardization of the raw materials for manufacture is of quite as great or even greater importance as the standardization in the successive phases of the industry. High-class production can only be attained when the farmer in America knows what the spinner wants. Waste and needless expense in the field of merchandizing, and in the processes of trade are a tax upon the well-being of the whole cotton trade, and can be avoided to a larger extent than is now the case through the adoption and application of universal standards.

Having in mind the benefits that have already attended a general use of uniform standards in the American markets, the Congress of the United States has passed a law that compels all transactions of grade in inter-state and foreign commerce to be in accordance with the grades hereafter to be known as the official Cotton Standards Act of the United States.

A brief discussion of the provisions of this law which was passed on March 2, 1923, will no doubt be of interest to the members of the International Federation of Master Cotton Spinners.

What the new United States cotton standard law requires.

The law compels every cotton merchant, shipper, buyer and trader in the United States in every transaction or shipment in inter-state or foreign commerce, and in every publication of prices, and in quotations of cotton for shipment in inter-state and foreign commerce, and in the classification of all cotton, to use the official cotton standards of the United States, provided the quality of the cotton involved in the transactions is of or within the range of the official cotton standards of the United States.

The law provides within these specific terms that its compulsory features shall not become effective until one year from the date on which the Secretary of Agriculture promulgates standards for the purposes of the law. In other words the logical and likely procedure is that at the close of the present cotton year or during the month of July, the Secretary will announce standards which at the expiration of 12 months of the date of this announcement will become compulsory upon all citizens of the United States.

Thereafter, bills of lading, warehouse certificates, shipping documents, insurance contracts, newspaper and private quotations of cotton by grade, invoices and all other documents will be required to be stated in accordance with official cotton standards.

The Act further provides in Section 2 that nothing therein shall prevent transactions otherwise lawful by actual sample or on the basis of a private type which is used in good faith and not as a means of evasion of or substitution for the official standards.

Any person who has the custody of, or a financial interest in, any cotton, may when the Act comes into full force submit the same or samples thereof, which must be drawn in accordance with

the regulations and safeguards imposed by the Secretary of Agriculture, to such officer or officers as the Secretary may designate for a true determination of the classification. The final certificate of the Department of Agriculture will be binding on all officers of the United States and will be accepted in the courts of the United States as *primâ facie* evidence of the true classification of the cotton itself or of the samples thereof when involved in any transaction or shipment in inter-state or foreign commerce.

The United States Government under the law is authorized to prepare copies of standards and to sell them at a cost to any person who may ask for the same. These copies are to be certified under the grade seal of the department, and the attachment of that seal will include regulations for the inspection, condemnation and exchange of standards in order to make certain that copies in use are accurate and suitable for commercial purposes.

Persons who tamper with, alter or change copies of standards excepting those who have the written authority of the United States Government to do so, or who use the standards with intent to deceive or defraud, or who counterfeit or simulate copies of the standards, are subject to a fine of $1,000 or imprisonment or both. The same penalties attach to persons who falsify or forge certificates, or who knowingly classify cotton improperly, and persons who knowingly influence, or attempt to influence improperly the classifiers licensed under the Act.

Conclusion.

The membership of the International Federation of Master Cotton Spinners has an undoubted interest in this whole matter as great users of American cotton. If the spinners in Europe, the merchants in Manchester and Liverpool, exporters and interior merchants in the United States, and the farmers of the American cotton belt can speak in identical terms so that each grade name will mean the same everywhere, an enormous advantage will be gained promoting economy and efficiency from first to last. [*International Cotton Bulletin*, No. 3, 1923.]

COTTON RESEARCH.

THROUGH the courtesy of the British Cotton Industry Research Association, the Secretary of the Indian Central Cotton Committee has sent the following abstracts for publication :—

CONTROL OF COTTON ANTHRACNOSE.

The development of anthracnose can be prevented by simultaneously heating and drying cotton seed in the absence of oxygen. In the presence of oxygen the fats and proteins of the seed appear to be oxidised so that the embryo is killed. The oxygen can be removed by evacuation or by introducing nitrogen into the drying tubes. After 26 hours heating of the seed in evacuated glass tubes in the presence of calcium chloride at 100°F. all fungi are destroyed and the germinating power of the seed is increased. [*Chem. Zentr.*, 1923, **1**, 1608; from *Amer. Fertilizer*, 1923, **58**, 32–34. G. F. LIPSCOMB and G. L. CORLEY.]

CLEANING OF COTTON.

Since dry cotton cleans better than wet cotton, equal cleaning can be attained with less damaging of the staple by airing and artificially drying cotton before feeding it to the openers, and subsequently lessening the beater action. The cotton could be mixed and stored for some days in a fireproof room provided with ventilators and radiators. The cotton must, however, be thoroughly conditioned before reaching the cards and the adoption of the above drying method would probably cause the use of atomisers for spraying moisture directly on to the lap to become more general. It is stated that an oil emulsion sprayed upon cotton will aid materially in the carding and also reduce the amount of fly. The practice of spraying soap solution, at present restricted to short staple and waste mills, to hold together the short fibres in the lap and prevent fly, is capable of development in the ordinary cotton industry. [*Cotton*, 1923, **87**, 659-660. R. B. SMITH.]

COTTONISING HEMP.

The possibility of augmenting the supply of raw material, or replacing part of the raw cotton employed in Germany by cottonised bast fibre is discussed and shown to be possible from an economic point of view if hemp is employed and the cultivation is carried on in co-operation with the cottonising process. Hemp can be cultivated on low-lying moorland of which approximately one million hectares are available in Germany. The mechanical and chemical processes of treating bast fibres, now employed, furnish a product very similar to cotton and capable of being spun on cotton spinning machinery. [*Z. angew. Chem.*, 1923, **36,** 129–130. P. WAENTIG.]

FORMATION OF CELL WALL.

As a result of a study of cotton and Tradescantia hairs, the author develops a theory of cell wall formation, based on the deposition of preformed particles of wall substances by the cytoplasm. Actual observations lead to the deduction that the cytoplasm rotates in a double spiral band, adjacent bands moving in opposite directions; this accounts for the striations, which occur along the stream lines, and the double lines of weakness at the junction of the bands. [*Jour. Text. Inst.*, 1923, **14,** T. 85–113. H. J. DENHAM.]

MICROSCOPY OF COTTON HAIR.

In connection with a study of the morphology of the cotton hair, details are given of the methods and reagents used in mounting the material. The interpretation of the microscopic images, under ordinary and polarised light, is also discussed and directions are given for detecting and obviating various optical falsities. [*Jour. Text. Inst.*, 1923, **14,** T. 85–113. H. J. DENHAM.]

MORPHOLOGY OF COTTON HAIR.

A study has been made of the various structures occurring in the wall of the cotton hair, and the origin of these structures

is discussed, partly with the aid of analogous material, such as Tradescantia hairs. The conclusions drawn are as follows:—

(1) Striations occur in all parts of the hair and in all layers of the wall; the direction followed is not always the same in superimposed layers. (2) Convolutions follow the direction of the primary striations. They are caused by a double spiral line of weakness in the hair, and are of four types; normal, movable, preformed, and suppressed. (3) Slip planes, like those observed in strained timber and in bast fibres, occur widely in cotton, and also lines of failure due to buckling. They are primarily due to internal stresses in the boll, and sometimes occur in a spiral plane or in elongated forms known as "beaded pits." (4) Some abnormalities in the cotton hair are due to the tendency of the hair to fill up all available boll space, limitations imposed by the size of the boll having a great influence on hair conformation. (5) No true pits exist in the wall, but areas of special permeability occur in a double spiral pattern. [*Jour. Text. Inst.*, 1923, **14,** T. 85–113. H. J. Denham.]

Structure of cotton hair.

Observations have been made on Sakel cotton, grown in a green-house, in the course of which three new methods were employed, namely, (1) observation in elliptically polarised light, (2) preparation of longitudinal sections, (3) development in the primary wall of a definite structure and of a substance reacting to cellulose stains, by boiling with potassium hydroxide. The following conclusions are drawn:—(1) The direction of convolutions formed in isolated hairs is entirely determined by the spiral reversals of wall construction. (2) Certain chemical relationships are indicated by the following facts:—(*a*) the wall does not fall into convolutions following mere plasmolysis, but does so on drying; (*b*) this loss of constructional water is irreversible; (*c*) the structural relationships to polarised light are but little affected by strong alkalis, but are readily abolished by acids. (3) Two cases of mirror image structure appear to exist in the hair wall though these do not necessarily imply stereo-isomerism. In both cases the surface of reversal is

at a normal to the current direction of growth : (*a*) the secondary wall visible structure is shown to form mirror images on either side of a reversal point ; (*b*) the primary wall structure is conjectured to consist of two concentric cylindrical layers (probably molecular) whose structures are mirror images. At reversal points these layers are presumed to change places. (4) The structures formerly termed "slow spirals" are designated "slip spirals" : (*a*) the slip spirals are now shown to be invariably opposed to the pit spirals, thus resembling cleavage planes ; (*b*) the single slip spiral of the cotton secondary wall is considered equivalent to the twinned slip spirals of wood cells, and it exists as a twin in the primary wall. (5) The number of structure reversals in the wall of one hair cell fluctuates round a mode in the neighbourhood of 30, indicating that a tendency to the formation of one complete reversal daily during growth in length is still a possible view : (*a*) the full number is present as soon as secondary thickening begins ; (*b*) no means for demonstrating the presumed reversals in the primary wall have yet been devised. (6) Two helical spirals have been found :—(*a*) one is seen in both primary and secondary wall (slip spiral) at 70° ; it is twinned right- and left-handed in the former only ; (*b*) the other in the secondary wall, called the pit spiral, appears to have a constructional angle of 29°, subsequently reduced by torsion during growth in thickness. (7) The tangents of these angles happen to stand almost exactly in the ratio of 4 : 1 which suggests polymerisation, as does also the change in number of extinction positions. (8) Some tentative speculations as to its ultimate structure are made in terms of a space-lattice hypothesis. [*Proc. Roy. Soc.*, 1923, **95B**, 72–89. W. L. BALLS.]

STRUCTURE OF COTTON HAIR WALL.

The spiro-fibrillar structure of the cotton cell-wall suggests that the wall is a sponge-like structure with (in the dry state) free air spaces therein. The specific gravity of cotton cellulose cell-walls, in their natural condition, is about 0·90 to 1·10. [*Proc. Roy. Soc.*, 1923, **95B**, 72. W. L. BALLS.]

MATHEMATICAL CONTROL OF FIELD PLOTS.

The author discusses the probable error concept in the interpretation of field experiments and emphasizes its importance. The formulæ in general use for the calculation of probable errors are explained and a new method, as well as a different way of using Bessel's and Peter's methods, is suggested. [*Jour. Amer. Soc. Agronomy*, 1923, **15**, 217–224. H. H. LOVE.]

Discussing some limitations in the application of the method of least squares to field experiments the author issues a warning against a too strict insistence on the application of the probable error and other constants. [*Jour. Amer. Soc. Agronomy*, 1923, **15**, 225–239. S. C. SALMON.]

PERSONAL NOTES, APPOINTMENTS AND TRANSFERS, MEETINGS AND CONFERENCES, ETC.

In the retirement of Rao Bahadur K. Rangachari, M.A., L.T., I.A.S., on 3rd September, 1923, the Madras Department of Agriculture has lost a Botanist of distinction.

After a brilliant educational career, Mr. Rangachari joined the Madras Museum where he made valuable additions to the specimens and improved their arrangement. The best part of his activities, however, began on his appointment as Lecturing Botanist at the newly opened Coimbatore Agricultural College. The facilities afforded by the well-equipped laboratories at the college brought out the best in him and helped him in producing the first Text Book on Botany for Indian students. It bears testimony to his wide knowledge and indefatigable industry and is being used as a Text Book in various arts and professional colleges. Last year he made another addition to the meagre literature on Indian botany by publishing " A Handbook of Some South Indian Grasses."

In recognition of his valuable work Mr. Rangachari was created a Rao Bahadur in 1913 and elected to preside over the Botanical Section of the Indian Science Congress in 1917. He acted as President of the Indian Botanical Society in 1922.

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On return from leave, Mr. S. Milligan, M.A., B.Sc., resumed the duties of Agricultural Adviser to the Government of India and Director, Agricultural Research Institute, Pusa, on 2nd November, 1923.

***

The services of Mr. M. J. Brett, M.R.C.V.S., Imperial Bacteriological Laboratory, Muktesar, have been placed at the disposal of the Government of the Punjab.

Mr. K. McLean, B.Sc., Offg. Fibre Expert to the Government of Bengal, has been granted leave for five weeks from 1st December, 1923, Mr. N. C. Bose officiating.

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Colonel A. Smith, F.R.C.V.S., Principal, Veterinary College, Bengal, has been permitted to retire from 25th December, 1923.

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Mr. M. H. Sowerby, M.R.C.V.S., Offg. Principal, Bombay Veterinary College, has been granted, from 1st August, 1924, combined leave for 15 months with permission to prefix the college vacation.

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Mr. G. Clarke, F.I.C., F.C.S., has been appointed to officiate as Director of Agriculture, United Provinces, *vice* Dr. H. M. Leake on deputation to the Soudan.

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The services of Dr. H. E. Annett, Opium Research Chemist, United Provinces, have been replaced at the disposal of the Government of India with effect from the expiry of leave granted to him.

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Mr. P. K. Dey, M.Sc., Plant Pathologist to Government, United Provinces, has been granted leave for three months from 12th November, 1923, Mr. S. D. Joshi officiating.

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Lala H. N. Batham, M.A., has been appointed to officiate as Agricultural Chemist to Government, United Provinces, *vice* Mr. G. Clarke on other duty.

***

Babu Sirish Chandra Banerji has been appointed to officiate as Assistant Agricultural Chemist, United Provinces, *vice* Lala H. N. Batham on other duty.

KHAN SAHEB MAHOMAD NAIB HUSSAIN has been appointed to officiate as Deputy Director of Agriculture, Rohilkhand Circle, United Provinces.

***

ON return from leave COLONEL G. K. WALKER, C.I.E., O.B.E., F.R.C.V.S., resumed charge of his duties as Principal of the Punjab Veterinary College, Lahore, on 1st October, 1923.

***

ON return from leave CAPTAIN E. SEWELL, M.C., M.R.C.V.S., resumed charge of his duties as Professor of Hygiene in the Punjab Veterinary College, Lahore, on 1st October, 1923.

***

MR. J. W. GRANT, M.A., B.SC., Deputy Director of Agriculture, Burma, has been posted to the charge of the Tenasserim Circle with headquarters at Moulmein from 1st December, 1923.

***

MR. T. D. STOCK, B.SC., D.I.C., A.R.C.S., Deputy Director of Agriculture, Myingyan Circle, Burma, has been nominated to be a member of the Indian Central Cotton Committee, Bombay, *vice* Mr. L. Lord.

***

ON reversion from the appointment of Agricultural Adviser to the Government of India and Director, Agricultural Research Institute, Pusa, Dr. D. CLOUSTON, C.I.E., has been reappointed Director of Agriculture, Central Provinces.

***

ON relief by Dr. D. Clouston, Mr. F. J. PLYMEN, A.C.G.I., has reverted to his substantive appointment of Agricultural Chemist, Central Provinces.

***

RAI BAHADUR KANAK LAL BARUA, B.L., has been appointed Director of Agriculture, Assam, in addition to his own duties as Director of Industries and Registrar, Co-operative Credit Societies, from 11th October, 1923.

Reviews

Insecticides and Fungicides ; Spraying and Dusting Equipment. A Laboratory Manual with Supplementary Text Material.—By O. G. Anderson, Professor of Horticulture, Purdue University, and F. C. Roth, Institute in Horticulture, Purdue University. Pp. xvi + 350 + 71 figs. (New York : John Wiley & Sons, Inc. ; London : Chapman and Hall.) Price, 15*s*. net.

This book is an excellent manual of the preparation and application of the various solutions and machines used to protect plants against pests and diseases, a subject on which a concise and modern compendium will prove very welcome to plant pathologists.

The first half of the book is written in the form of a series of laboratory exercises. Each exercise contains directions for the preparation and use of an insecticide or fungicide followed by a few questions to test the student's knowledge. The sources from which the information necessary to answer the questions may be best obtained are sometimes indicated by references to current literature, by no means the least valuable feature of this work. Some fifty exercises in the first half of the book are taken up in this manner and the remaining 25 deal chiefly with fumigation, dusting and the various types of spraying machinery. This section of the book should prove of utility both to those engaged in instructional work in colleges and technical institutes and to growers and others engaged in practical and commercial phases of the horticultural industry. The authors have wisely eschewed the complex chemistry of the various spraying solutions, and the practical man will not find himself bewildered by formulæ and scientific information which he cannot with advantage assimilate.

The second half of the book contains chapters on the control of insect and fungal diseases and on modern types of spraying and dusting machinery.

The chapter on fungal diseases has been contributed by Dr. Max W. Gardner. This author groups the method of control of plant diseases under five headings: (1) Exclusion, (2) Extermination, (3) Inhibition, (4) Protection, (5) Disease Resistance.

Exclusion is carried out in most civilized countries by regulations which prohibit and restrict the importation of living plants from foreign countries. The author points out how chestnut blight and white pine blister rust entered the United States with foreign stock and how the potato warty disease entered with imported seed tubers. In this country many will be familiar with the regulations designed to prevent the introduction of the latter disease into India.

As examples of the control of fungal diseases by the total extermination of the parasite the author quotes the citrus canker campaign in Florida, soil disinfection, the control of smut diseases by seed steeping and the control of powdery mildews on gooseberry and roses, and of peach leaf curl by spraying. Except in the case of the steam sterilization of the soil of small seed beds it appears doubtful to the reviewer whether absolute extermination of a parasite can ever be secured, although quite satisfactory control of a disease may be obtained. Thus in India complete control of peach leaf curl in the North-West Frontier Province is obtained on those orchards which have adopted dormant spraying with lime sulphur.

The control of fungal diseases by inhibition implies the adoption of some agricultural practice which acts adversely to the success of the parasite without appreciably affecting the host. Thus, in addition to the ordinary sanitary precautions which fall under this head, heterœcious parasites may be controlled by the eradication of the alternative host, e.g., stem rust of wheat and apple rust. In India, however, the wheat rust problem could scarcely be solved on these lines. Alterations in the soil reaction by special manuring may also give control of a parasite. Liming the soil against cabbage club root and the application of sulphur against potato scab are well known, and, in India, manuring with potash has been found to lessen the incidence of stem rot in jute.

By protection is meant the application of a poisonous substance to the exterior of the plant before it has become infected. This

is usually carried out by spraying or dusting with a fungicide. In India the crops which are sprayed are chiefly tea, fruit orchards, and other valuable crops, such as areca-nuts. Dusting has not yet been carried out on an appreciable scale in this country and indeed the relative merit of dusting and spraying is yet a debated question.

The control of a disease by the introduction of a variety of the host which is immune to the attack of the parasite is familiar to all agriculturists--the wheat crop perhaps furnishing the best example.

The chapter on the control of plant diseases is followed by several others devoted to a description of modern spraying and dusting machinery. As the authors truly remark, " if a spraying machine built ten years ago could be exhibited and compared with the latest model by an expert, the improvements and changes would be even more numerous and impressive than a similar comparison of automobiles." This part of the book is of great interest both for the number and types of the most modern machines described and illustrated and as a revelation to workers in other countries of the extent to which high powered spraying is practised in the United States of America. The machines described and figured range from a Hand Atomizer to a 5-ton motor truck working at a pressure of 1,000 lb. The book concludes with two useful chapters on dusting and the operation of the gas engine.

In a subject which is developing and changing as rapidly as plant pathology it is impossible for any work to remain for long the last word on fungicides and spraying. The authors, however, are to be congratulated in that, at the present moment, they have succeeded in collecting and arranging in an accessible form the vast mass of information scattered through the scientific and technical journals of plant pathology, agriculture and horticulture. [F. J. F. S.]

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Manual of Dairy Farming.—By B. K. GHARE, College of Agriculture, Cawnpore.

MR. GHARE has shown considerable care and some knowledge of Indian conditions in compiling this work which deals briefly with soils, manures, cultivation; housing, feeding and management

of cattle ; milk production, dairy products, tests for dairy products and the principles of cattle breeding. The arrangement of the book would be improved if Part IV—Cattle Breeding—followed or preceded Part II—Cattle Management. The book is largely a compilation of what has been written by various writers concerning European, American, and Indian dairying, and does not attempt to set forth results of original work in the direction of dairy research done by the writer in India, but all the same the writer shows a genuine appreciation of dairy conditions in India and the book is certainly a valuable addition to the scanty literature available concerning the dairy industry in this country.

The general principles applicable to Indian dairying laid down in the book are sound, and well and clearly stated, but the figures given as to the average yields, periods of lactation, etc., of Indian breeds of dairy cattle cannot be accepted as correct. They evidently refer to those of specially selected animals or herds, and it is a practical impossibility to-day to go into the market and purchase any reasonable number of either Gir, Mewati or Montgomery cows which would give the yields of milk per lactation quoted by Mr. Ghare, and it would be a very difficult matter and take a very long time to obtain in commercial quantities either Sindi cows, Delhi, Jafferabadi or Surti buffaloes which would come up to the standard of milk yield given in this book.

The description of various Indian dairy breeds given, although brief, is concise and correct, and, taken on the whole, the book can be recommended as a suitable text-book for agricultural students, and for all interested in the dairy industry in India. [W. S.]

NEW BOOKS

ON AGRICULTURE AND ALLIED SUBJECTS.

1. Heredity in Poultry, by R. C. Punnett. Pp. xi+204+12 plates. (London : Macmillan & Co.) Price, 10*s.* net.
2. Botany : Principles and Problems, by E. W. Sinnott. (London : McGraw Hill Publishing Co.) Price, 15*s.*
3. Cotton and the Cotton Market, by W. Hustace Hubbard. Pp. xii+503. (London: D. Appleton & Co.) Price, 16*s.* net.
4. Oleaginous Products and Vegetable Oils : Production and Trade. Pp. xxxiv+511. (Rome : International Institute of Agriculture.)
5. Methods of Seed Analysis, by C. B. Saunders. Pp. 15. (Cambridge : National Institute of Agricultural Botany.) Price, 1*s.*
6. The Cultivation of Sugarcane in Java, by R. A. Quintus. Pp. xii+168. Illustrated. (London : Norman Rodger.) Price, 12*s.* net.
7. Researches on Fungi, by Prof. A. H. Reginald Buller. Vol. 2 : Further investigations upon the production and liberation of spores in Hymenomycetes. Pp. xii+492. (London : Longmans, Green & Co.) Price, 25*s.*
8. The Story of the Maize Plant, by P. Weatherwax. Pp. xv+247. (London : Cambridge University Press.) Price, 1·75 dollars.
9. Commercial Poultry Raising, by H. A. Roberts. Pp. 607. (London : Chapman and Hall.) Price, 15*s.* net.
10. The Foundations of Agricultural Economics, by J. A. Venn. Pp. xv+397. (Cambridge : At the University Press.) Price, 16*s.* net.

11. Farm Management, by W. J. Spillman. Pp. 500. (New York: Orange Judd Publishing Company, Inc.) Price, 3 dollars.

THE following publications have been issued by the Imperial Department of Agriculture in India since our last issue :—

Bulletins.

1. The Improvement of Fodder and Forage in India (Papers read before a Joint Meeting of the Sections of Agriculture and Botany, Indian Science Congress, Lucknow, 1923), edited by Gabrielle L. C. Howard, M.A. (Pusa Bulletin 150.) Price, As. 6.
2. A Method for the accurate determination of Carbonic Acid present as Carbonate in Soils, by Phani Bhusan Sanyal, M.Sc. (Pusa Bulletin 151.) Price, As. 2.

Report.

3. Scientific Reports of the Agricultural Research Institute, Pusa (including the Reports of the Imperial Dairy Expert and Secretary, Sugar Bureau), for the year 1922-23. Price, R. 1.

THE HAWK-CUCKOO (*HIEROCOCCYX VARIUS*).

Original Articles

SOME COMMON INDIAN BIRDS

No. 26. THE HAWK-CUCKOO (*HIEROCOCCYX VARIUS*).

BY

T. BAINBRIGGE FLETCHER, R.N., F.L.S., F.E.S., F.Z.S.,
Imperial Entomologist;

AND

C. M. INGLIS, M.B.O.U., F.E.S., F.Z.S.

The common name "Hawk-Cuckoo" conveys a good description of this bird, as it is really a Cuckoo which looks very like a hawk. It is about the size of a mynah, but with a longer tail, greyish-brown in colour, whitish beneath, the breast tinged with pink, each feather with darker cross-bars, eyes and legs brilliant yellow. When on the wing, it looks very much like a small hawk but, when it alights, it at once assumes a slouching, cuckoo-like attitude, with the wings dropped forward so as to touch the perch and the tail slightly raised and expanded, thus presenting an aspect very different from the compact and alert look of a hawk. Seen thus, at rest, this bird can hardly be mistaken for a true hawk, as it has the furtive, peering ways of common cuckoos, constantly jerking itself from side to side and puffing out its throat.

The appearance of the Hawk-Cuckoo is probably less familiar to most people than is its note, which has aptly earned for it the notorious title of the "Brain-Fever Bird." Our Indian gardens and groves contain many sweet-voiced singers amongst their avian

denizens and a few whose voices are less grateful to the ear, but there is not one whose notes consist of such ear-splitting and nerve-racking cries as do those of the Brain-Fever Bird. With the most annoying persistence and reiteration this bird repeats its cry, which bears a remarkable resemblance to the word " brain-fever " repeated in a piercing shriek running up the scale. The cry may also be

Head and foot of Hawk-Cuckoo (*Hierococcyx varius*).

written as " Pipiha " and in some districts the vernacular name of the bird is given as *Pupiya*. Another rendering of the call, which includes the overture preceding the triple note, is, " O lor' ! O lor' ! how very hot it's getting—we feel it, *we feel it*, WE FEEL IT." The call is extremely loud and shrill and can be heard—indeed, it cannot but be heard—within a radius of several hundred yards,

but one of the most annoying things about it is its intermittent character. The human ear soon becomes accustomed to any continuous and uniform kind of noise. One becomes so accustomed to the buzz of a dynamo that one awakens at once if it stops. The copper-smith *tonk-tonking* in the garden all day is hardly heard consciously unless one listens for it. But the shrieks of the Brain-Fever Bird burst their way without ceremony into one's inner consciousness, whether awake or asleep, and one cannot help but hear them. "We feel it, *we feel it*, WE FEEL IT" go the cries, up and up the scale, and then suddenly stop, and one hopes fervently that this fiend in bird's plumage has burst its throat or at least flown away out of ear-shot. But no; after a short interval it begins again and may continue for hours at a stretch. Very often the performance commences just at dusk, when it has got too dark to make out the culprit, and lasts all night without intermission. When this sort of thing takes place on a really hot night, the victim, who is attempting to woo sleep after a hard day's work, may well be excused if the first dim dawn sees him sallying forth on vengeance bent. But vengeance is not always easy to attain. The bird usually perches high up in a tall tree and keeps so still and is so inconspicuously coloured that, even when its shrieks locate the very branch whereon it is sitting, it is not always easy to make out. Further more, it is wary and often flies off as soon as it sees that it has been detected. There are, however, usually only a few individuals in each locality and a comparatively small reduction in numbers works wonders in abating the nuisance. The call being very penetrating, it often happens that these birds call to one another across a distance of perhaps half a mile and, by shooting one bird forming a link in the chain between others on either side of it, the chain is broken, and a blessed peace reigns once more, at least until another bird invades the immediate neighbourhood. In Bihar the call of this bird coincides with the approach and duration of the hot, dry weather before the monsoon; occasionally it may be heard as early as in December but more usually commences about February and is continued, becoming more frequent and continuous, until the Rains break, when there is a welcome cessation for a few months.

In other districts this may not be so; thus, as regards Calcutta, Cunningham states that "there is hardly any season at which their characteristic notes may not occasionally be heard; but, as a rule, it is during the rainy months that they are most frequent, so that the designation 'hot-weather bird,' that is often applied to the species in other parts of the country, is hardly applicable to it in Calcutta."

According to Blanford, the Hawk-Cuckoo occurs throughout the whole of India and Ceylon, extending as far East as Dacca, but not to Assam, and West to Rajputana, but not to Sind or the Punjab; but, although odd examples may occur throughout this area, its range as a common bird seems to be more restricted. It is extremely common in the United Provinces and Bihar, less common further south in Bengal. Dewar notes that he never heard it in Madras, nor did I ever hear it during my residence in Coimbatore, and it is apparently quite absent in the island of Bombay. In some districts in which it is absent, or at least scarce, the Hawk-Cuckoo is frequently confounded with the Koel and the name "Brain-Fever Bird" given to the latter. As Dewar puts it, "There is certainly some excuse for the mistake, for both are cuckoos and both are exceedingly noisy creatures; but the cry of the koel bears to that of the brain-fever bird or hawk-cuckoo much the same relation as the melody of the organ-grinder does to that of a full German band. Most men are willing to offer either the solitary Italian or the Teutonic gang a penny to go into the next street, but, if forced to choose between them, select the organ-grinder as the lesser of the two evils. In the same way, most people find the fluty note of the koel less obnoxious than the shriek of the hawk-cuckoo."

In spite of its obnoxious vocal efforts, the Hawk-Cuckoo does some little good by feeding on injurious insects, although when it can find time to hunt these out in the height of the hot weather, when it seems to be calling continuously day and night, always seems somewhat of a mystery. Like other cuckoos, it eats hairy caterpillars, whose defensive armament protects them from the attacks of most other birds, and it also eats other caterpillars,

crickets, grasshoppers, bugs and beetles. The diet is a mixed one, comprising buds and fruits, particularly wild fig fruits, as well as insects. It is presumably on account of this redeeming feature that this bird is protected in Delhi, the United Provinces, Bengal and Assam (where, however, it does not occur !).

Like other Cuckoos, the Brain-Fever Bird economizes in house-keeping, building no nest of its own but placing its eggs in the nests of other birds, usually the "Seven Sisters" or some allied species of Babblers, the breeding-season lasting from April until June. The eggs are deep blue in colour and measure about 26 mm. by 20 mm., and are about the same size and shape as those of the foster-parents. The Babbler's eggs are wholly blue, very glossy, hard-shelled and broad, blunt ovals in shape; the Hawk-Cuckoo's eggs are very similar in colour but with a softer, more satiny surface, less glossy and with much thicker shells, in shape rather more spherical or elliptical and slightly larger than in the Babblers. When lying side by side in the nest, however, the eggs of the Babbler and of the parasitic Cuckoo are often practically indistinguishable.

The manner in which Cuckoos' eggs are deposited in the nests of other birds is one which has engaged a great deal of attention. It used to be supposed that the eggs were laid in the normal way in the nest of the birds selected as foster-parents and this may occasionally be done, but the more frequent method is for the egg to be laid and then carried by the cuckoo in its bill and dropped into the nest selected for the purpose. The unusually thick texture of the cuckoo egg-shell seems to be specially adapted to this end as, in cases where the nest is placed inside a hole, the egg may have to be dropped into it from a little height. In the case of the Hawk-Cuckoo, it is possible that its hawk-like appearance on the wing may be advantageous in securing a clear field for depositing an egg in this way in the nest of the Seven Sisters, as one observer states that the whole sisterhood make themselves scarce when the Hawk-Cuckoo appears on the scene, and thus give her a fair field for planting her oval imposition on them. Our Plate shows a Hawk-Cuckoo, with an egg in her bill, about to be dropped into the nest of one of these Babblers. It may be added that further observations,

on the method of egg-deposition employed by this and other Indian Cuckoos, are very desirable.

The Hawk-Cuckoo is known vernacularly as *Kupak* and *Pupiya* in Hindi-speaking districts, as *Chok-gallo* in Bengal, as *Zakkhat* in the Deccan, as *Irolan* in Malayalam and as *Kutti-pitta* in Telugu districts.

PLATE V.

INTERNATIONAL CATTLE BREEDING CONGRESS, 1923.
H. R. H. PRINCE HENRY IS MARKED WITH A CROSS.

INTERNATIONAL CONGRESS ON CATTLE BREEDING.

BY

G. S. HENDERSON, N.D.A., N.D.D.,

Imperial Agriculturist.

The International Congress on Cattle Breeding was held at Scheveningen near the Hague beginning 29th August, 1923. The general attendance was good and there were representatives from all parts of the world (Plate V).

The subjects under discussion were as follows:—

Section I. Department of Science—

(*a*) Which new ideas and opinions about the doctrine of the heredity should be considered to be of importance for cattle breeding?

(*b*) Which are the opinions of recent date about the method of feeding?

Section II. Department of Registration—

(*a*) Which data should be mentioned in the cattle herd-book and how will this information have to be collected so that there will be a sufficient guarantee as to its correctness?

The method of recording the production of milk not to be taken into account here.

(*b*) In which way shall the control (production) of milk be carried out, and is it possible to make international regulations about this?

Section III. Interference and care of public authorities and influence of associations—

(*a*) In which way could the breeding of cattle be promoted by the public authorities by other than veterinary measures?

(*b*) In which way would it be possible for associations, whose object it is to improve the cattle stock, to make a practical use of the information to be obtained through science and registration?

Section IV. Economical breeding—

(*a*) Which points will have to be taken into consideration when selecting a breed for a certain type of an agricultural enterprise?

(*b*) How could tuberculosis among cattle be combated in a practical way and what is the experience of different countries in this respect?

Subject I (*a*) on heredity was an interesting sub-section and a summary of a paper by Professor Kronacher is appended. A summary of the paper by Professor Per Tuff is also given.

Summary of paper by Prof. Kronacher.

(*a*)

Selection in breeding signifies nothing else than making use, in practice, of the laws of nature with regard to heredity. Ample knowledge of the results of the laws of heredity that have been acquired is therefore of especial significance for the breeder of cattle. For cattle breeding, the most importance must be attached, in the first place, to the results of investigations in the following three spheres of the law with respect to heredity: the genotype and the phænotype doctrines of Johannsen, the mutation doctrine according to de Vries and also the teachings of Mendel, further developed by many investigators during the past twenty years.

(*b*)

1. The work from Johannsen and his school shows that the differences in the development of distinctive marks and characteristics, among the several individuals, may only be the result and expression of the difference of conditions of life (phænotypical differences, modifications) or they may be the expression of genotypical differences.

Both of these causes may also co-operate, as is the case of foreign impregnation, as occurs in by far the most instances in the manner of our domestic animals.

Owing to the difference of the causes, the value also of the variations among the individual domestic animal is defined for selective breeding.

The appearance and the performances of a breeding animal are unable to tell us anything concerning its breeding and heredity value, because we are not able, without anything else, to see which of the two causes in question, in the particular case, gave rise to the different development of certain characteristics in the individuals to be judged. This can only be ascertained when it is known how the following generation has turned out.

From these views concerning the doctrines of variation and selection of recent times, ignorance and neglect of which has caused great loss of capital and work on breeding to practical cattle raising, the extraordinarily great importance of the individual for selection is seen, and also the necessity of the examination of its progeny—respectively its value as regards heredity, by virtue of the results of that progeny. The breeder must, as far as possible, use for his breeding exclusively those animals whose advantageous characteristics, with respect to breeding, as regards build of body and performances, are the expression, primarily, of an inherited susceptibility, which, even under average circumstances, is to be seen to equally great advantage.

The idea of heredity of acquired characteristics, as if the development (modification) of certain parts of the body and their activity (performances), acquired during the individual lives of the animals under the influence of circumstances, via the one or other course, is transmitted on the germ cells, respectively, the prevailing susceptibility to heredity, is not compatible with the theory mentioned with respect to this; nor is any support to be obtained for this theory from the extensive experimental investigations in that sphere, least of all, however, from the experience gained in cattle breeding itself. For, if inheritance of acquired characteristics, in the above-mentioned sense, and a continual

progressive alteration of the total hereditary possession accompanying this, owing to selective breeding, that has been carefully conducted in one direction for such a long time now, took place, in all sheds, where breeding has been carried on efficiently, there would now be exemplary herds in every district.

There are, however, enough ways and means for the cattle breeder to achieve his purpose, even without such speculations as the presumption of the heredity of acquired characteristics, in the foregoing sense.

2. Among a homozygote and heterozygote herd, sudden, spontaneous changes of the susceptibility to heredity occur (changes of the genotype) which make themselves manifest as changes of heredity, occurring under similar conditions, of the actual exterior distinctive marks or performances (changes of the phænotype), mutations. Such a mutation is to be observed among plants, among the lower and higher animals, including our domestic mammals. They may be due to a loss of a factor of heredity, the qualitative or quantitative character of a prevailing factor, or the acquisition of a new. Concerning the occurrences and causes that effect such changes in the germ plasma, so far, nothing is known with any degree of certainty. It would, however, appear that besides inner, exterior influences, via the circuitous route of general alimination, both the body cells as well as the germ cells may be influenced and changes may be affected. Whether in each particular case one has to do with a " mutation " or a " modification," can only be decided by observations among the progeny. Modifications, particularly of quantitative characteristics, which presumably occur more often than is generally supposed, can, as a matter of fact, also be of a less obvious character and even then be within the normal lines of modification. Then, however, since they result in a continual removal of the *average*, in the development of the characteristics in question, under certain circumstances they are of great significance for the results of selection. Further, what is known so far concerning mutation, shows us again the extraordinary importance of the single individual in selection and the necessity of determining its breeding value by means of the

progeny; there is also, however, the necessity of fixing, in figures, the build of body and the performances of the animals in the succession of generations.

3. The Mendel investigations have shown, with absolute certainty, that every factor of heredity (situated in the chromosomen) for the most varying morphological and physiological characteristics behaves, in the process of heredity, perfectly independently, and that on crossing (bastard forming) the introduced hereditary factors in the succeeding generations are subject, according to fixed laws, to a splitting up; it has almost always been possible to find a natural explanation that is quite compatible with this.

Whether, in a few exceptional cases heredity has taken place according to other laws than those regarding the splitting up of the cells, or perhaps also to certain characteristics of the animal body, are not determined by special natural disposition in the kernel, but are general alimentary characteristics of the entire plasma, both of the body and the germ cells, is a question that has remained unanswered down to the present. In any case, the Mendel law of separation, apart from such disappearing and hitherto unknown exceptions, is generally of application, also for the process of heredity among our domestic animals.

With this insight, a great number of conceptions and ideas, which, until quite recently, had an overwhelming influence upon the views of breeders, must disappear. Before everything else, breeders must, once and for all, give up the idea of the existence of a "constant intermediary heredity," of the occurrence of existing middle formations remaining alike for longer than the first generation, on the pairing of animals of similar or different breeds with, in certain directions, opposite hereditary dispositions. But even the view of an arbitrary possibility of mixing characteristics generally, expressed by the terms $\frac{3}{4}$ths, $\frac{7}{8}$ths, $\frac{15}{16}$ths blood, etc., will have to be rejected.

The fact that has been ascertained, that it is not the type of animal as such that is inherited, that the natural disposition of characteristics does not form one whole in the process of heredity, but that, on the contrary, the separate factors of heredity

take their own course, gives us a second insight that is extremely important for the practice of breeding: the insight of the possibility, in principle, of a systematic combination in one, of the various distinctive marks and characteristics, hitherto distributed throughout several hereditary types and races, i.e., the insight into the possibilities and means for the breeding of new hereditary types and races, by means of crossings.

A decisive influence upon the entire forming of the meanings, and general effective mode of thought in breeding, has been the chief consequence of the results of the new doctrine of heredity and especially of the two fundamental views of the Mendel doctrine.

The consequence of these altered ideas in the world of breeding will be: uniform general methods of breeding and a uniform explanation of the appearances which occur on the carrying on of breeding, as these, as a matter of fact, are already beginning to occur everywhere in breeders' circles.

(*c*)

Regarding the question concerning special possibilities of making use, in practical breeding, of the new doctrines of heredity:

1. The method of the choice of individual breeding which must fix the "breeding (as to heredity) value" (in contrast to the "personal value") of a breeding animal and, under certain circumstances, also its homozygote and heterozygote disposition in connection with results of the progeny, as a consequence of its pairings for crossings, respectively, of trial pairings. In practice, it appears that the method of pairing for crossings, which must serve especially for the fixing of the heredity of quantitative characteristics, for the larger domestic animals, however, this is only possible under certain conditions, for the purpose of approving male breeding animals. Even here, however, from an economic point of view, fixed limits have been set for the application of this method as a result of the numerous characteristics that are generally to be taken into account, but also owing to the slow process of increase and the long time before being capable of use, by the larger domestic animals. The method that has been applied, for some time past, upon which

fixing the powers of performance must be based, in England and other countries is experimental.

In order to achieve a result responding to this, it would seem to be necessary to limit oneself, primarily, to the observance of one or just a very few of the most important characteristics and then systematically, one after the other, according to their significance, bring these within the method of selection. For an easier and more certain insight into the heredity disposition of the parents to be approved with respect to quantitative disposition, in the very first place, it would appear also to be effective that the offspring should be reared under normal or even moderate, but in no case under especially favourable circumstances, seeing that otherwise, in such cases, the difference between favourable modifications of moderate and bad hereditary disposition is not to be distinguished from an inferior development of very good hereditary disposition. Those individuals which give evidence, also under comparatively simple conditions of life, of bodily development and performances of high value, are just of the greatest importance to the breeder.

The fact that the Mendel doctrine has laid it down that a whole number of distinctive marks and characteristics of our domestic animals, the so-called quantitative characteristics according to the nature of the quantity of milk, the percentage of fat, etc., just the most important for breeding, are apparently determined by factors of heredity, working, more or less, in the same direction, in any case combining their work, facilitates for the breeder the insight into the symptoms acting in this connection and simultaneously with this the work of cattle breeding. It shows him, in the first place, how indispensable it is to know how the progeny turns out, if he is desirous of correctly estimating the breeding value of the parents, and, secondly, the necessity of the exact carrying out of examinations concerning performances.

For the more extensive practical use of the possibility of an effective combination of economically valuable characteristics, distributed among several races, in one breed, by a systematically

founded scientific method, especially for the larger and the largest domestic animals, in a great measure, so far, further knowledge of the nature and the conduct of the hereditary disposition, which determines the economically most important, and in the special case, the characteristics especially required, is lacking. Those methods which, as a matter of fact, are already being applied at the present time with some systematic experiments, even after we shall possess the further knowledge necessary for this, with respect to the main thing determining hereditary disposition, it will still be difficult and especially for complicated combination breeding, the application will continue to be limited. In any case, however, especially for times of drastic change in economic conditions and the need accompanying these of a new formation of the stock of cattle, as also for special occasions, not to be underestimated for prospects for the affecting of an alteration of the stock of cattle, within a corresponding period that will adapt itself, as well as possible, to the altered or special circumstances.

The new doctrine of heredity has an exceptionally lasting influence upon the mode of thought of the breeder, and with this, upon the general measures and the judgment of the results of breeding.

It shows breeders the necessity of making use of individual selective breeding on the basis of the result of the progeny, and shows him the ways and means, truly limited, indispensable to this for breeding domestic animals.

The views of the Mendel doctrine give the breeder very valuable general particulars and also even many special points for combination in carrying on selection in breeding. For any scientifically systematic carrying on of selection, both within a breed, especially with a view to attaining as good results as possible from combination breeding, further knowledge concerning the nature and the conduct of the definite factor of heredity is still lacking.

It is in the interests of the economic breeding itself of domestic animals to investigate in all directions the question of heredity among domestic animals, especially by supporting existing or newly established institutions for biological research and to promote

as extensive as possible herd-book relations available for the investigation of heredity.

Summary of paper by Professor Per Tuff.

The analysis and investigation of the characteristics and circumstances of heredity in our breeds of cattle must be based primarily on the particulars of the herd-books. Those herd-book particulars are also of great significance for studying the results of various methods of breeding. It would therefore be desirable that the herd-books should be compiled according to a common international plan, so that the particulars from individuals should be similar, complete and as reliable as possible.

By a systematic selection in breeding, it may be attained that within one and the same breed, the herd will acquire a similar exterior, but an uncertain heredity. A system of in-breeding will not only support a choice of breed for similar characteristics, it will also result in a lasting and certain heredity.

The effect of selection in breeding, as regards recessive and dominant characteristics, is different. A recessive characteristic immediately becomes homozygote and will certainly be transferred. Selective breeding of a dominant characteristic, will, in the end, lead to homozygosis ; this, however, takes place very gradually. Dominant characteristics, based upon homomere factors, practically speaking, cannot become homozygote solely by selective breeding.

The effect of in-breeding consists in this, that it leads, automatically, to homozygosis of all tendency to characteristics. Harmful results from in-breeding are consequent on the splitting up of recessive weaknesses. Most of the old races of cattle are based upon in-breeding ; they are kept intact by this means and are indebted for their constant heredity to this. Simultaneously they have been purified, in a great measure, from disintegrated constitutional weaknesses. Such races, as a rule, will stand in-breeding well. An example of this is seen in the Telemark cattle in Norway. Young races of cattle, and races in which in-breeding has not taken place, will generally not be able to stand this well, and in that case, care must be taken with the application of this method of breeding.

Any harmful results of in-breeding can immediately be got rid of by the introduction of new blood.

It would be desirable that in-breeding should find greater application in practical cattle breeding, as a valuable means of fixing good characteristics, so that these be transferred. Where in-breeding can be applied, greater advantage will also be able to be taken of valuable covering bulls, by allowing these to serve closely related cows (such as, e.g., daughters or grand-daughters).

Probably Wright's[1] in-breeding co-efficient is the best of the various measures or expressions for the degree of in-breeding, as this gives, in a good way, the homozygosis achieved.

Colonel Matson, of the Indian Military Dairy Farms, contributed a paper on the results of crossing of Indian cattle with European breeds.

Subject I (*b*) on feeding was largely of a physiological nature. Some of the chemists present using the languages of their respective countries could not be followed by the writer, but judging from the tone of the discussion there seemed to be some serious differences of opinions.

Subject II was concerned with registration, and discussion ranged round the necessary particulars required in herd-books and other registration forms.

It was pointed out in discussion that a Friesian breeder in Australia might import stock from America, England or Holland and get animals with very different characteristics.

Subject III (*a*) on promotion of cattle breeding by the State is of considerable interest to India. The following summary of a paper by Dr. Attinger gives a catalogue of means whereby the State can usefully help on cattle breeding.

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[1] Wright, Sewall. Co-efficients of In-breeding. *American Naturalist*, Vol. LVI. 1922. . 320.

SUMMARY OF PAPER BY DR. ATTINGER.

Cattle breeding in all civilized countries enjoys more or less encouragement on the part of the State, because the welfare and food-supply of the nation is dependent upon its development. The many uses to which cattle are put, raise the cow above the other agricultural domestic animals.

It may also be said and proven that the height of the development of cattle breeding is a standard for judging the civilization of a nation. The State is therefore bound to promote the development of stock-keeping.

This may be done by :—

1. Measures in connection with the cultivation of food-crops and the supply of fodder. The cultivation of food-crops forms the basis for the raising of cattle. Those measures have reference to the improvement of pasture lands, the promotion of susceptibility to this, extension of the cultivation of food crops on agricultural land, appointment of advisers, inspectors of seed cultivation, etc. The putting of peat grounds and heath under cultivation, the facilitating of the import of fodder in times of failed harvests.

2. Promotion of the health condition of the cattle, education and advice for breeders in the sphere of feeding, pasture, shed and breeding hygiene.

3. Legal regulations concerning characteristics, the keeping, examination and use for breeding purposes of the male breeding animals (compulsory examination).

4. Promotion of the investigation of powers of production, the training of milk inspectors, the holding of shows and exhibitions with classes for production, institution of controlling associations.

5. The establishment of Government model industries and model breeding farms. Those establishments must not be set up at great cost, which cannot be emulated by the breeders, but the establishments, as regards equipment, manner of working and profit making, will have to be examples capable of being followed by every breeder.

6. Promotion of associations in the sphere of cattle breeding, the appointment of official experts in cattle breeding or by granting

assistance towards their appointment. As breeding associations are the pioneers of the progress of cattle breeding, these should be strongly supported by the State.

7. Thorough training, theoretically and in practice, of breeders in Higher, Secondary and Lower Schools of Agriculture, the foundation of cattle-breeding institutes, the conducting of special courses for cattle breeding, the care of cattle, the regulations regarding food, milking, etc. Promotion of the granting of certificates of suitability to special cattle attendants.

8. Promotion of the holding of shows, examinations of cattle, exhibitions of fattened cattle, public sales of breeding-bulls, the acquiring of lower freights, Government premiums, medals.

9. The appointment of expert cattle-breeding officials, establishment of departments for cattle breeding at the Ministries for Agriculture, the conduct of cattle breeding from a central place.

10. Other measures: the regulation of the import and export of cattle, protective rights, supervision of the cattle trade and markets, effective policy regarding prices, Government cattle insurance, the furnishing of credit in accordance with the needs of the times, support for the great, important activities throughout the whole sphere of cattle breeding.

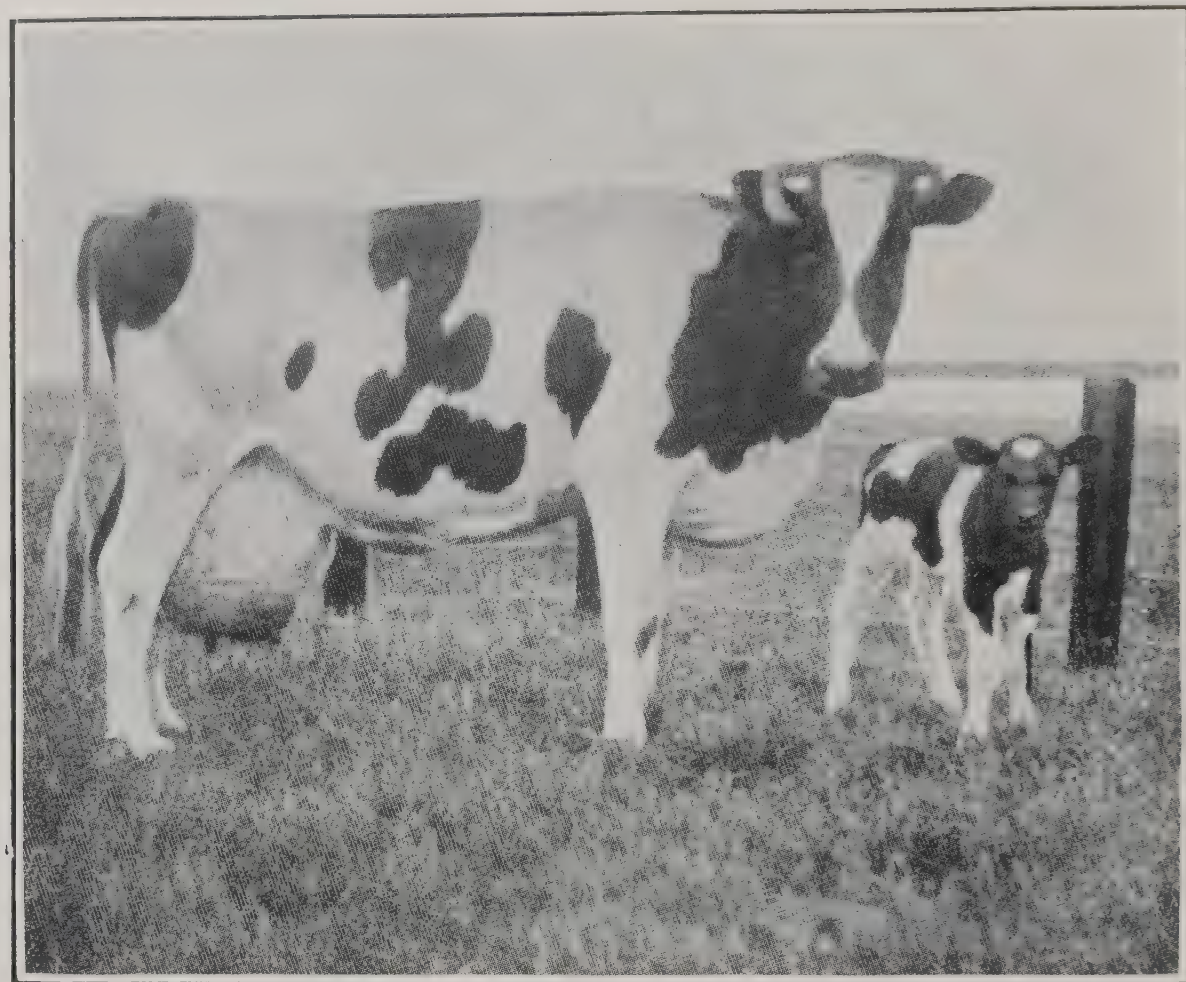
Subject III (*b*) was not of particular interest and few papers were forwarded.

Subject IV produced a paper by Dr. Ulrich Duerst of Berne which starts an original line of investigation. A summary of his paper is as follows:—

"Answering to the question I conclude from the last researches of my own laboratory:

1. The cattle to choose in any race must firstly have a constitutional type corresponding with the desired production.

2. To produce large milk and beef quantities the animal to choose must show a relative small content of dry-substance in its blood.



STIENSER XI, No. 9130 F. H.
(Born 10th March 1896, with her 13th calf.)

RIENK, No. 11132 F. H. (Born 22nd March 1919.)

3. To produce a higher quality of milk (butter-cows) or animals of early-maturity in fattening, we must choose them with a higher degree of blood-dry-substance.

4. To possess a resistent constitution and to be able to stand long journeys (exportation cattle) we must choose cattle with a dark colour without much albino-spots and owning a high degree of blood alkalinity."

Some photos of Dutch cattle are given (Plate VI). The writer was struck with the hardy appearance of the stock seen. There was a conspicuous absence of the coddling usually associated with pedigree milk herds. The cows had to yield milk under ordinary commercial farming conditions or they were quickly got rid of. The general stock to be seen were large, thrifty, commercial animals with big frames and with all the signs of constitution. This is probably why Dutch milk cattle have been a success all over the world.

NOTES ON COTTON BOLLWORM ATTACK AT SURAT.

BY

M. L. PATEL, B.Ag.,
Cotton Breeder, South Gujarat.

In considering the yield of the cotton crop in South Gujarat, and particularly at Surat, over a series of years, two features at once strike the observer. The first is the extraordinary variability of the yield, which is not at all completely explicable by variations in rainfall; the second is the curious way in which, as compared with similar figures for other countries, the early flowering appears to be checked. Before presenting the observations which the author has made in order to proceed towards an explanation of these phenomena, we may look more closely at the facts themselves.

The variability of the cotton crop can be fairly well measured by the average yield of seed-cotton obtained on the Surat farm. For a number of years this is as follows, the total actual rainfall being placed side by side with the figures of yield :—

Year	Average yield of seed-cotton in lb.	Total rainfall in inches
1900	87	34·19
1904	242	13·40
1910	415	32·09
1911	91	17·30
1912	643	51·68
1915	296	26·90
1918	405	17·65
1920	631	25·02

The connection of yield with total rainfall is very slight. The two highest yields were obtained with 25 and with over 51 inches, and the lowest with a rainfall of over 34 inches. The more these figures and others on record are critically examined, the more it is clear that when the rainfall exceeds 17 inches, neither its amount nor its distribution is the dominant influence in determining the yield. A similar examination of temperature records shows no direct influence either of the average maximum or minimum temperatures on the yield of cotton. There is, however, a suspicion that a low cold weather temperature has an injurious effect on the yield of cotton in the succeeding year.

As it seemed clear that some non-climatic influence was affecting yield, the author has, during the last five years, in order to elucidate the question, carefully studied the appearance of flower-buds and flowers, and determined the proportion of these which ultimately forms bolls. Now in cottons belonging to *Gossypium herbaceum* (which include practically all important Gujarat cottons), ordinarily the flower-buds on the first primary fruiting branch (sympodium), on which the flower-buds are formed earliest, appear from the sixth to the ninth week after germination. The period is by no means definite, of course, and varies according to soil and season. Thus, at Surat, with the commonly grown Broach *desi* types of cotton, this branch gave its first flower-buds as follows in the last five years :—

Year	Appearance of first flower-buds
1918–19	6th to 8th week
1919–20	6th to 8th week
1920–21	5th to 6th week
1921–22	10th to 11th week
1922–23	7th to 9th week

As the flower-bud takes almost exactly a month to ripen into a flower, it follows that flowers should begin to appear a month later than the first flower-buds.

This, however, rarely occurs, and the first flowers are usually much later. In the last five seasons the first flowers opened as follows :—

Year	Appearance of first flowers	Time between first buds and first flowers
1918–19	12th week	4 to 6 weeks
1919–20	17th week	9 to 11 weeks
1920–21	15th week	9 to 10 weeks
1921–22	16th week	5 to 6 weeks
1922–23	15th week	6 to 8 weeks

These figures clearly indicate the entrance of a factor, more powerful in some seasons than in others, which causes a large shedding of flower-buds at the beginning of the season, and so brings about delay in flowering due to shedding of flower-buds. This is unusual in other cotton-growing countries, where by far the largest part of the shedding most commonly takes place at the end of the season. This loss of flower-buds is, it seems clear, to by far the largest extent, caused by the spotted bollworm (*Earias* sp.) though other sucking insects, notably Jassids and *Aphis*, are probably indirectly responsible for a small portion of it. The fact that a very large proportion of fallen flower-buds are pierced with bollworm punctures makes it clear that this insect is the principal offender.

This very large (in some cases almost complete) loss of the early flower-buds tends to make the actual flowering concentrated in a very short period. With two of the author's pure strains this concentration is shown below for the last five years. The figures show the proportion of the total flowers formed which appear in the most intense flowering four weeks.

	Strain "1A Long Boll"	Strain "1027 A.L.F."
	Per cent.	Per cent.
1919–20 (24th to 27th week) ..	63·0	67·4
1920–21 (20th to 23rd week) ..	72·5	83·5
1921–22 (24th to 27th week) ..	65·8	64·7
1922–23 (22nd to 25th week) ..	67·6	70·9

Now out of these four weeks of intense flowering, the bulk of the actually successful bolls was produced from flowers opening in *two* weeks only. This is shown in the following table, which shows the percentage of the flowers opening, which ultimately produced ripe bolls.

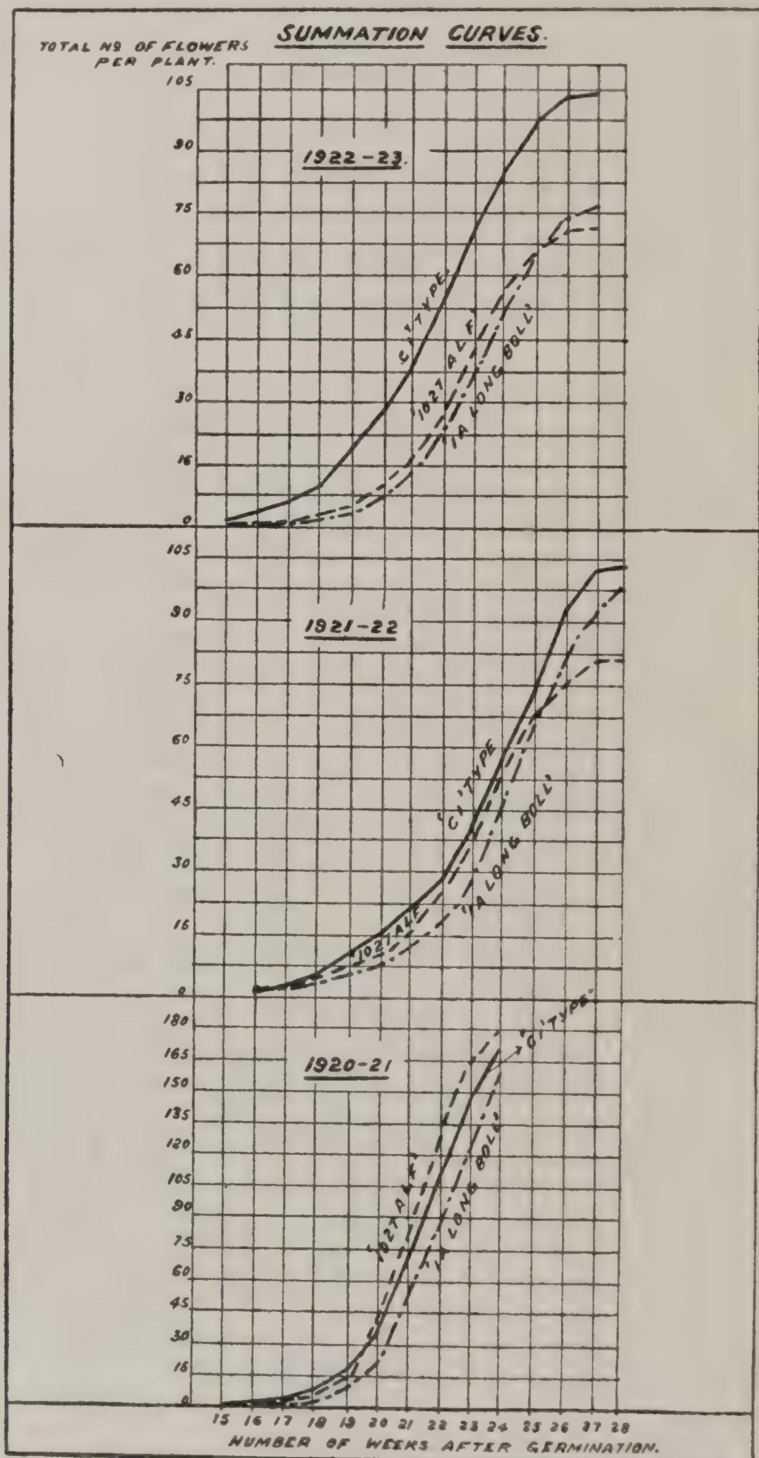
	Strain " 1A Long Boll "	Strain " 1027 A.L.F."
	Per cent.	Per cent.
1920–21		
1st week	72·0	69·0
2nd week	67·0	36·0
3rd week	38·5	18·5
4th week	16·0	8·5
1921–22		
1st week	63·0	58·0
2nd week	58·0	45·0
3rd week	28·5	10·0
4th week	4·0	1·5
1922–23		
1st week	66·4	57·0
2nd week	52·0	54·2
3rd week	30·1	15·7
4th week	7·7	5·7

Thus the major portion of the ultimate cotton crop *is produced from the flowers opening in two weeks.* This is more true, of course, of some strains than of others, and those pure strains which have either a tall open habit of growth, or a spreading habit of the bracts of the flower-buds, or a large proportion of flowers to leaves, seem to have a longer *effective* flowering season than others. It would appear, however, that if the *effective* flowering period could be lengthened, the yield would be greater though the early produce will be diseased. It was obvious almost immediately that a very important cause not only of the failure of the early flowers but also of the later flowers to some extent was the spotted bollworm (*Earias* sp.), which is thus a great factor in shortening the effective flowering season.

The facts just brought out are illustrated very well by a series of curves * representing the flowering of the plants belonging to pure

* These curves are framed on the lines suggested by J. A. Prescott in his studies of the flowering of the Egyptian cotton plant. (*Ann. Bot.*, **36** (1922), p. 121.)

strains of cotton grown at Surat. These curves for three such strains are shown below for three years. They show the total



number of flowers formed up to any particular date, and on comparison with those for Egypt, for instance, it will be noticed that there is a very marked check in the early part of the flowering,

and then a sudden rise in the number of flowers formed. This check, which does not occur in Egypt or, for the matter of that, in any other area even in India to the same extent, is, as has been noted, due, in by far the largest measure, to the effect of the spotted bollworm.

How proportionately great is the effect of the spotted bollworm is shown by the following set of figures in which is shown the total shedding of flower-buds, flowers and bolls on four plants, which, on a careful examination of the shed material, is due to bollworm and to other causes.* The figures given show the number of flower-buds, flowers and bolls shed :—

Month	Shedding due to bollworm	Shedding due to all causes except bollworm
November 1920	226	66
December 1920	124	659
January 1921	19	397
Total ..	369	1,122

It will be seen that even though the sheddings of October were not counted, by far the greater part of the early loss is due to bollworm, but that its relative importance tends to disappear later in the season.

Three points seem, therefore, clear :—

(1) The relatively small yield of Broach *desi* cottons at Surat is largely due to the fact that there is a very obvious check to the flowering of the early formed flower-buds.

(2) This check causes the *effective* flowering period to be very short.

(3) This check in the early season is chiefly due to the work of the spotted bollworm (*Earias*). The pink bollworm appears later in the season, but is not a serious danger at the time we are now considering.

* The actual examinations were made by Mr. T. N. Jhaveri, Assistant Entomologist, to whom our thanks are due.

If these conclusions are correct, then the checking of the spotted bollworm is the most important thing to be done to increase the outturn of cotton in Lower Gujarat. So far efforts in this direction have taken three lines, and we will now review what has been done in these directions and its general value. These three methods are—

(*a*) To grow a trap crop along with cotton, and then remove this crop and destroy it. The trap crop usually employed has been *bhindi* (*Hibiscus esculentus*) or ladies-finger.

(*b*) To destroy the earlier broods of the bollworm by removing the top shoots of the cotton plants.

(*c*) To catch the paired moths when they are dormant, that is to say in the early morning and in the evening.

When the first of these methods was tried, namely, the growth of *bhindi* as a trap crop, the following observations were made. The attack of the pest was first noticed at the beginning of September. From that time onward till the first week in October, after which the trap crop was removed, fifty-six pounds of *bhindi* fruits were removed, from which 744 worms were killed. During the same time 899 worms were obtained from the top shoots of the cotton crop immediately surrounding. In the trap crop the heaviest infestation was found when the harvest was finishing in the beginning of October, and at that time the attack on the cotton was less than in the *bhindi*. It will thus be seen that the trap crop was not so attractive as to prevent attack of the cotton while it was present, though it had a greater proportion of attack than the main crop.

On the other hand, the moths themselves were not at their maximum until after the trap crop had been removed. In 1920, a campaign to kill the paired moths (as per method (*c*) above) was made from October to the middle of December and the number so killed was as follows:—

September	9 pairs
October 1st to 23rd	21 pairs
October 24th to 31st	235 pairs
Total October	256 pairs
November	579 pairs
December 1st to 16th	177 pairs

While searching for the paired moths, all punctured flower-buds, flowers, and immature fruits which were found on the cotton and on the trap crop were removed and the worms destroyed. The number of worms so removed and destroyed was as follows :—

Number of worms removed and destroyed.

	From trap crop	From cotton	Total
September	185	474	659
October first week	559	425	984
October 8th to 31st	..	261	261
November 1st to 19th	..	1,234	1,234
November 20th to December 16th ..	..	282	282

The figures furnish a good indication of the severity of the attack.

It is clear, therefore, that the system hitherto in vogue of sowing a trap crop with the cotton and removing the *bhindi* pods as they mature is almost useless, as the maximum attack occurs after the *bhindi* is removed. Even when the trap crop is present, there is still a large amount of attack on the cotton, and as a means of removing the early broods of the bollworm and so *preventing* the serious attack of the cotton, the method definitely fails. Whether there is a possibility of *checking* the attack, by having successive crops of *bhindi*, is not yet clear and has not been tested.

With regard to the second suggested method of check, it may be noted that, up to the third week of October, the attack of the bollworm was chiefly on the young growing shoots of the plant, either on the petioles of the leaves or on the flower-buds. After that date, it occurred equally on all kinds of immature fruit forms. Now, from the previous table, it will be seen that the maximum emergence of moths takes place from the last week in October and through November. Thus the removal of the top shoots of the young plants will not be effective unless all or nearly all such shoots

are removed, for the bollworm moth has the habit of depositing its very numerous eggs singly in a large number of places. Its life-cycle takes about a month, so that the eggs deposited near the end of September will give the moths which produce the very heavy broods of moths at the end of October. Inasmuch as it is impossible to remove all or even a large proportion of the growing shoots of the plants at the end of September or in early October when the cotton is making its growth, the method seems definitely to fail and has, in fact, produced little advantage in practice.

The advantage of using all the above mentioned methods on a single area of cotton, that is to say, the growing of a trap crop (*bhindi*) among the cotton, the nipping off top shoots in the early season, and the destruction of moths in the morning and evening, was tested by noting the percentage of diseased and healthy flowers opening each day on a fully treated area and on an adjoining untreated area during two weeks at the most important part of the season. The results are as follows:—

	Percentage of attack	
	Treated area	Untreated area
	Per cent.	Per cent.
November 20	9·5	17·1
" 21	10·7	16·3
" 22	12·6	15·0
" 23	8·0	15·6
Average	10·2	15·6
December 7	3·3	4·7
" 8	1·9	6·4
" 9	2·7	4·9
" 10	1·0	3·0
Average	2·2	4·7

The real benefit obtained by the application of all these methods was tested by comparing the percentage of success of flowers from flower-buds, and of bolls from flowers, in the general area of the farm in 1920-21 and 1921-22, with the success on an

area where all the methods were tried in 1922-23. With two pure strains the figures were as follows :—

	Percentage of success	
	Strain " 1A Long Boll "	Strain " 1027 A.L.F."
1. Flower-buds to flowers—		
1920–21	39·3	36·5
1921–22	39·7	44·1
1922–23	30·0	33·9
2. Flowers to bolls—		
1920–21	38·0	36·0
1921–22	32·0	38·5
1922–23	35·6	36·0

That the pest gets a check suddenly from 5th of December and onward can be judged from the following table showing the percentage of diseased bolls from flowers opening in different weeks in two of the strains in 1922.

	Strain " 1A Long Boll "	Strain " 1027 A.L.F."
	Per cent.	Per cent.
From bolls, up to 5-12-22 ..	70·0	73·6
6th to 12th December	51·7	56·2
13th to 19th December	37·5	48·1
20th to 26th December	28·2	39·1
27th December and onwards ..	15·7	36·0

In short, there is apparently a distinct effect of the measures used, but the remaining attack is so great that, as practical effective measures, they are not worth the cost and trouble involved.

The amount of attack remaining is so great as to ensure full infestation of the crop in the later stages. The absence of greater effect would seem probably to be due to the fact that a single pair of moths can produce an enormous amount of infestation owing to their method of depositing the eggs singly in many separate places, so that a smaller number of moths left undetected may and will probably lead to almost a maximum amount of damage later in the season.

The figures above noted do, however, show one very striking fact, namely, the sudden and very large reduction in the proportion of diseased flowers between the third week in November and the second week in December. This is coincident with the sudden appearance at the end of November or beginning of December of worms heavily parasitized with a small wasp, *Microbracon lefroyi*, which is also very active in the Punjab. In the latter part of November, in fact, worms were found in numbers in a moribund condition. Several of the larvæ of the wasp responsible for the parasitism were found on each worm and the full-grown insect emerged after ten days, following eight days' pupation. The natural supposition would be that this parasite, whose appearance coincides with a sudden fall in the percentage of attack, is probably the cause of the sudden reduction in the amount of infection. There is as yet no proof that this is the case, but the substantial failure of other methods of reducing the severity of attack would lead one to look upon the cultivation of this parasite as the most promising method of dealing with the pest in Gujarat.

SOME ASPECTS OF LARGE ESTATE FARMING IN THE PUNJAB.*

BY

W. ROBERTS, B.Sc.,

British Cotton Growing Association Farm, Khanewal.

THE Punjab Government when colonizing the Lower Bari Doab tract allotted certain large size grants of land on lease for specific purposes. The following are the main grants being worked at present :—

Area in acres	Lessee	Purpose
21,000	Military Farms Department ..	To produce fodder for the Army.
7,000	Col. Cole ..	Horse breeding conditions—roughly one breeding mare per square of 25 acres to be kept.
7,000	Major Venrenen ..	
2,000	Hon. S. Jogendra Singh	Steam cultivation.
2,000 to 4,000	Ch. Jehangir Khan ..	Cattle breeding—a definite number of breeding cows kept per square.
	Ch. Allahadad Khan and others (five in all)	
3,000	Mr. Conville ..	Seed production for the Agricultural Department.
7,000	British Cotton Growing Association ..	To encourage staple cotton growing, test varieties, establish a buying agency for long staple cotton, etc.

A total of about 60,000 acres has thus been allotted—this corresponds to $\frac{1}{2}$ per cent. only of the irrigated tract of 12 million acres in the Punjab and less than $\frac{1}{4}$ per cent. of the cultivated area of the province. All these farms with the exception of that of the Hon. S. Jogendra Singh are worked on the tenant system and *batai*, i.e., the tenant gets half the produce and the landlord half;

* Paper read at the Indian Science Congress, Bangalore, 1924.

the water rate and land revenue and taxes which total about Rs. 9 per acre being paid half by the landlord and half by the tenant.

The great bulk of the irrigated colonies has been allotted to small farmers who hold from one to five squares, i.e., from 25 to 125 acres. The conditions of the leases of the large estates mentioned above are much stricter and more severe in every way than those granted to the small cultivator.

The writer has been managing the B. C. G. A. estate at Khanewal for the last three years. A few of the ways in which this estate especially, and others incidentally, benefit the country are noted below.

Supervising staff.

Owing to the areas being large it is possible to engage qualified men from the Lyallpur College, where the writer worked for 12 years, as assistants. The Association employs at present five graduates or diplomates of the college, besides an honours graduate just recruited from home, whose qualifications in botany it is hoped to utilize to supplement and help the work of the Agricultural Department.

Cultivation of cotton.

Special attention is given to the cultivation of cotton. About 1,800 acres of irrigated cotton are grown annually. The average yield last year for 1,300 acres of American cotton was 12 maunds of $82\frac{2}{7}$ lb. per acre and for *desi* cotton $15\frac{3}{4}$ standard maunds. No other large or even small estate in the Punjab can point to such results. The yields in the present season* are expected to be at least equally good, as judged from pickings so far received and the general condition of the crop. The general method of cotton cultivation at the farm is as follows:—

The land in the colonies is divided into squares of 25 acres, five acres each way and numbered from 1 to 25. Each line of five acres in a square is divided into two, thus giving ten units of $2\frac{1}{2}$ acres in each square. Three such lines per square are generally

* Final yields for 1923-24 are: American 14 maunds per acre on 1,400 acres and *desi* 15·1 maunds on 600 acres.

put down to cotton. These are always together and are continued in the next square, so that a line $2\frac{1}{2}$ acres wide may often stretch for ten or even more squares. This enables the irrigation water to be concentrated on these blocks and on the adjoining fodder block, the fallow areas not being touched. This leads to economy and concentration of water, and is a big factor in securing the best result from the water available. Had cotton been sown in odd acres all over a square, much water would be wasted in being taken along various channels; of which comparatively little use was made. The same thing applies, of course, to wheat and other crops, which are also concentrated in blocks.

During the latter part of March and early April, experience shows that excess of water is available in the canals. Use is made of this by giving land prepared for cotton double *rauni*, i.e., two waterings before sowing. This secures good tilth and a well supplied subsoil water reserve. After sowing, the crop gets no further water for from six to ten weeks, and has thus an opportunity to develop deep roots, and to get well into the soil, thus insuring better resistance to drought, should water supply be short later on.

If rain falls after sowing, the crust is immediately broken by means of the "bar harrow" which is very popular on the estate. All cotton is sown in lines either two feet apart (*desi* cotton) or three feet for American. The crop is intercultured as often as possible and especially after irrigation. Generally from four to six intercultures are given. It may be mentioned that the usual system of cotton sowing in the Punjab is broadcast, and no interculture is possible with that system. The native plough is actually run through the crop, even when it has been broadcasted, but observation shows much damage is thus done to young plants, especially of American cotton, and such fields are characterized by plentiful weeds, which cannot flourish except at the expense of the cotton crop.

As cultivation is done on a large scale, uniformity throughout the farm is rapidly attained. Instructions are given out from week to week and day to day as to what operations are to be

performed and what crops require watering, etc. In this work the Lambardars (headmen) appointed from among the tenants, and by them, give invaluable assistance. There has been no slowness in appreciating the value of system and control, for, after all, the tenant gets half the produce while the supervising staff, implements, etc., fall entirely on the estate or landlord.

Buying agency.

Again, assistance is given in selling produce, for which a premium over the ordinary market qualities is always available. In order to facilitate the securing of best prices for cotton the Association has established its own buying agency and tenants' cotton is bought at premiums over the market rate. Other large zemindars who sell to the Association and can produce uniform quality cotton also receive premiums.

Pure seed.

Great attention is paid to the supply of pure seed. Sufficient to sow a lakh of acres of cotton was supplied either to the Agricultural Department, or direct to the cultivators last season. Similarly as regards wheat as much seed as is wanted can be supplied at market rates.

Assistance to Agricultural Department.

In order to facilitate the work of the Agricultural Department, large scale tests of varieties are carried out by growing types alongside one another and recording yields separately. It is hoped thus to secure early results as to the value of new varieties (constantly being produced by the department) when tested under ordinary conditions away from Government farms.

Report to Government.

A report is sent each year to Government on the value of the Punjab-American cotton in Liverpool and Lancashire, thus tending to keep the grower in touch with the value of long staple cotton as compared to *desi*.

Power cultivation.

Among other lines of work being started is investigation of power cultivation, whether from tractors or steam, as compared to tenant farming. As large tracts will shortly be coming under cultivation for the first time, both in the Punjab and Sind, and as, under present conditions, settling and colonizing a new tract is slow work, after the completion of a canal, it is hoped very important economic results will be worked out. It is very probable, as far as existing evidence goes, that assistance during the first years of colonization will materially reduce the project costs estimated for such canals as the Sutlej Valley in the Punjab and the Sukkur Barrage in Sind.

A very instructive experiment in tractor cultivation is in progress on Major Venrenen's estate where 2,000 acres are being managed in this way, with apparently very successful results. A great many problems, however, still remain to be solved, especially as regards comparison of tractors and steam cultivation.

A feature of most of the estates is the well planned villages, roads, trees and wells put up by the lessees for their tenants and labourers--whose prosperity and contentment must be considered in all successful estate management.

CARBON DIOXIDE IN SOIL GASES.*

BY

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First Assistant to the Imperial Agricultural Chemist.

It must have been observed by many that fruit trees do not grow so well on plots which are never weeded out, as on those which are kept free from weeds by surface cultivation. This fact is demonstrated in the botanical orchard at Pusa, where there are three plots, one of which has been grassed down, one kept cultivated, and a third which has been grassed but provided with trenches ($1\frac{1}{2}$ ft. wide and 2 ft. deep, filled with gravel) between rows of trees. Although all the three plots were planted at the same time, fruit trees grown on the cultivated plot are quite vigorous and are far superior to those on the other two plots, while those grown on the trenched grassed plot are slightly better than those on the grassed plot without trenches. The trees on the grassed plot are not only of very poor and stunted growth, but some of them are actually dead. This fact was brought to the notice of the Chemical Section at Pusa about four years ago, and an investigation was at once commenced.

During the first year 1919, attention was confined only to the periodical examination of the CO_2 content of the soil gases from these three plots. The method adopted for the collection of soil gas samples and the determinations of their CO_2 content was quite simple. For each determination about 10 litres of soil gases were aspirated through a Reiset's apparatus connected at one end, by means of capillary tube and a tap, to a brass tube driven inside the soil and at the other end to a 15-litre aspirator bottle. The

* Paper read at the Indian Science Congress, Lucknow, 1923.

Reiset's apparatus contained a measured volume of baryta water, the strength of which was determined before and after aspiration of the soil gas by titration against standard acid and the titration differences gave the data for calculating the amount of CO_2 contained in the soil gas.

The results for 1919 (Table I) show that the proportion of CO_2 has been considerably higher in the grassed plot than in the cultivated plot ; the trenched grassed plot results being intermediate

TABLE I.

Months during which soil gas was examined	PLOT No. 1 GRASSED DOWN			PLOT No. 2 GRASSED BUT PARTIALLY AERATED BY TRENCHES			PLOT No. 3 SURFACE CULTIVATED		
	1919 % CO_2	1920 % CO_2	1921 % CO_2	1919 % CO_2	1920 % CO_2	1921 % CO_2	1919 % CO_2	1920 % CO_2	1921 % CO_2
January ..	0·444	0·342	0·375	0·312	0·250	0·294	0·269	0·186	0·247
February	0·472	0·382	0·331	0·320	0·342	0·282	0·253	0·238	0·248
March ..	0·427	0·457	0·315	0·223	0·383	0·302	0·197	0·236	0·233
April ..	0·454	0·367	0·514	0·262	0·321	0·430	0·203	0·222	0·315
May ..	0·271	0·385	0·374	0·257	0·315	0·322	0·133	0·235	0·277
June ..	0·341	0·544	0·448	0·274	0·524	0·421	0·249	0·275	0·296
July ..	1·540	1·113	1·421	1·090	0·906	1·219	0·304	0·334	0·378
August ..	1·590	2·036	2·280	0·836	0·993	1·648	0·401	0·307	0·542
September	1·908	2·212	1·620	0·931	1·167	1·206	0·450	0·341	0·442
October ..	1·297	1·545	1·268	0·602	0·718	0·805	0·365	0·291	0·300
November	0·853	0·647	0·873	0·456	0·420	0·513	0·261	0·254	0·264
December	0·398	0·441	0·669	0·327	0·341	0·373	0·219	0·277	0·273

in character. During the first six months of the year, the carbon dioxide in the soil gas of the grassed and trenched plots varied between 0·50 and 0·25 per cent. and that in the cultivated plot between 0·30 and 0·15 per cent. The CO_2 was at its lowest in all the three plots during May when the weather was very hot and dry. Immediately after the commencement of the monsoon, the CO_2 in all the three plots suddenly rose and continued increasing

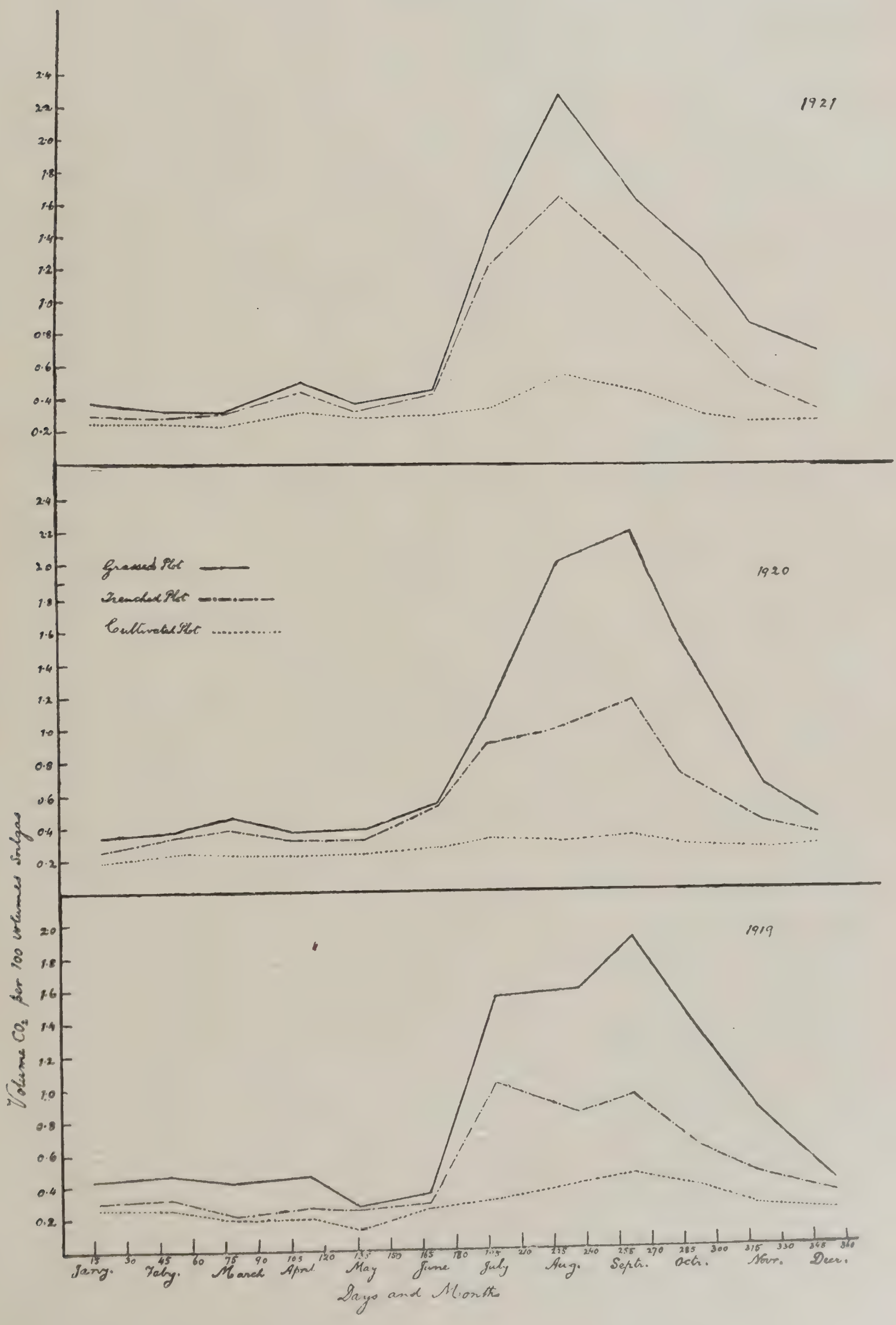
till it reached its maximum point between August and September. In the grassed plot, the figure rose to about 2 per cent., in the trenched plot to about 1 per cent. and in the cultivated plot to about 0·45 per cent. CO_2. With the ceasing of the rainfall in October, the CO_2 content decreased until in December it fell to 0·4, 0·3 and 0·2 per cent. respectively. These rises and falls were most pronounced in the grassed plot and less marked in the trenched plot, whereas the variation in the cultivated plot was only slight (Chart I). Chart I shows the seasonal variation in the CO_2 content of the soil gas from three plots.

In the following years 1920 and 1921, the periodical examinations of the CO_2 content of the soil gases from the three plots were continued. The results obtained during these years were quite analogous to those obtained in 1919, as will be evident from Table I giving the values obtained during three years 1919 to 1921. The soil atmosphere of the grassed plot is uniformly much richer in CO_2 than that of the cultivated plot, and this difference is most marked during monsoon months.

The rise and fall of the CO_2 content of the soil gas could not be correlated with the rise and fall of subsoil water level. An attempt was made to determine the CO_2 contents in the gases below a depth of 10 ft. from the surface, in September 1921, when the water level stood highest. The CO_2 content at this depth approximately worked out to 1·3 per cent. when the corresponding CO_2 content below 1 ft. was 1·62 per cent. The very great increase in the CO_2 content of the grassed plot during the monsoon month would seem to be associated with the presence of moisture in the soil at 1 ft. depth, and the explanation of a few abnormal figures obtained in March 1920 and April 1921 is to be found in this; on both these occasions, there had been some rain about four or five days previous to the examination of soil gas and consequently there had been an appreciable increase in the CO_2 content of the soil gas from the grassed plot.

In order to confirm the conclusion that the formation of increased amount of CO_2 in the soil gas of the grassed plot is due to the presence of moisture, two plots of ground were selected in the

CHART I.


1921
1920
1919
Grassed Plot
Trenched Plot
Cultivated Plot
Volume CO2 per 100 volumes Soilgas
Jany.
Feby.
March
April
May
June
July
Aug.
Septr.
Octr.
Novr.
Decr.
Days and Month

pot culture house compound, both of which were kept grassed over, but, of which, one was irrigated throughout the hot season, the other remaining under normal conditions. Before commencing the experiments, the CO_2 content was determined and found to be 0·474 per cent. in No. 1 and 0·492 per cent. in No. 2. The results obtained subsequent to commencing the irrigation of Plot No. 1 were as follows:—

TABLE II.

Date	Plot I Irrigated	Plot II Unirrigated
April 7th	0·984	0·441
" 12th	0·864	0·410
" 24th	1·000	0·435
May 8th	1·002	0·364
" 20th	0·819	0·335
June 2nd	0·779	0·349

It may, therefore, be taken as clearly demonstrated that the effect of keeping plots grassed over is to enormously increase the CO_2 content of the soil gas during periods of rainfall and that the presence of moisture is the determining factor.

Examination of moisture content of the soil up to a depth of 18 inches, in all the three plots, throughout the year (Table III) showed that, during April and May, the moisture content of the soil at 1 ft. to 1 ft. 6 in. in the grassed plot goes down to about 1 per cent., in the trenched plot to about 1·3 per cent. and in the cultivated plot only to about 5·5 per cent. It is, therefore, evident that the soil in the grassed plot becomes so depleted of moisture that a large proportion of grass roots die during hot weather. Consequently during the monsoon, conditions are favourable to a rapid decomposition of the organic detritus introduced into the soil from the roots of the grass, carbon dioxide being one of the products of this decomposition.

Brown and Escombe[1] found that the response, which all the species of flowering plants make, to a slight increase in the amount

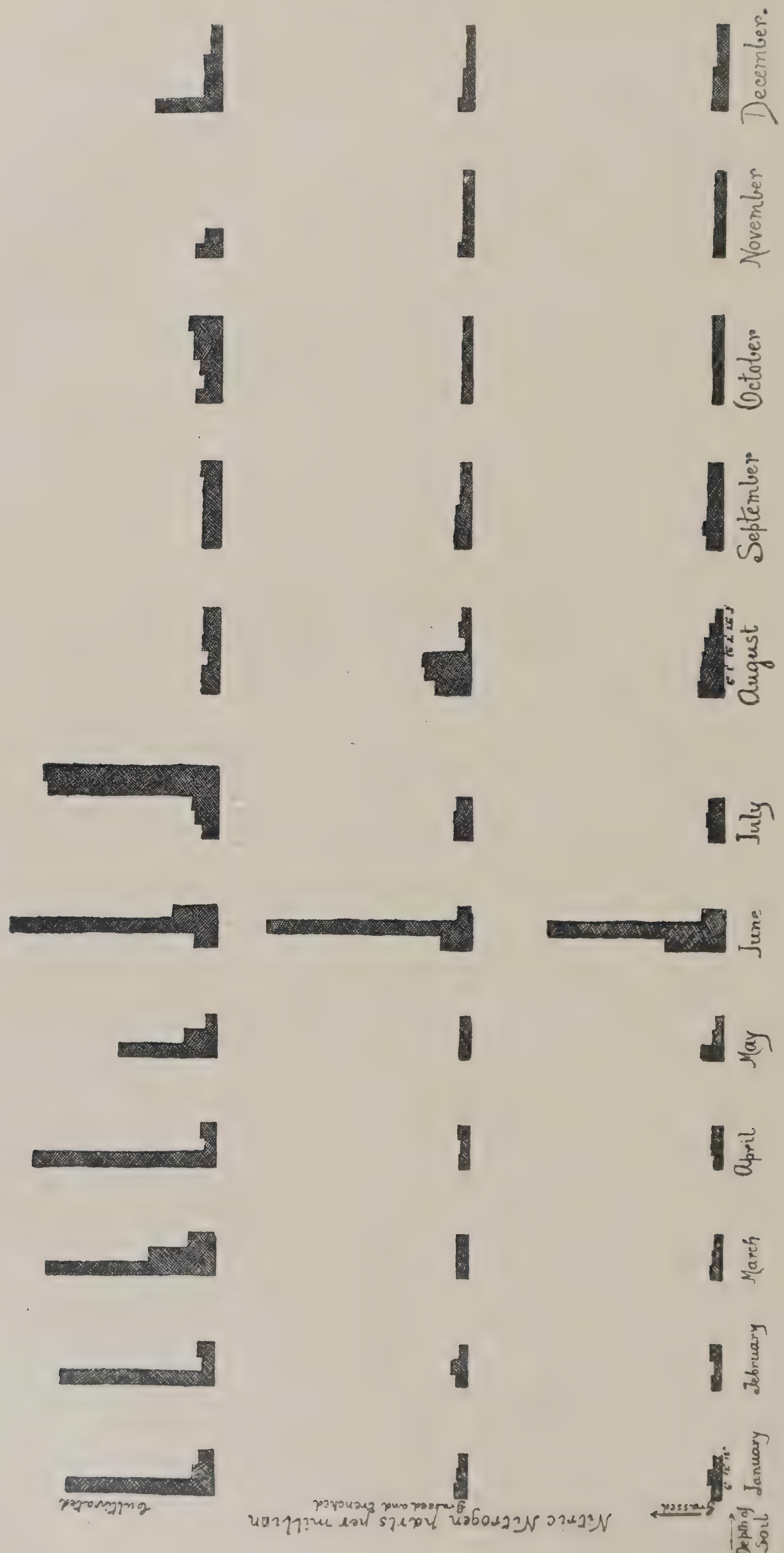
[1] *Royal Soc. Proc.*, **76**, p. 351, 1905.

of CO_2 is in a direction altogether unfavourable to their growth and reproduction, and that a comparatively sudden increase of CO_2 in the air to the extent of but 2 to 3 times the present amount would result in the speedy destruction of nearly all flowering plants. Cannon[1], while carrying on a series of experiments, in which the roots of *Prosopis velutina* and of *Opuntia versicolor* were exposed to an atmosphere of (1) pure CO_2, (2) atmospheric air, so diluted with CO_2 that a mixture containing 5 to 25 per cent. oxygen resulted, found that there is retardation of growth with increasing amounts of CO_2 and that the roots of both *Prosopis* and *Opuntia* can maintain only a feeble growth rate in an atmosphere containing as little as 5 per cent. oxygen, but that root growth in both species stops in pure CO_2. As the action of excess of CO_2 in the soil in retarding plant growth has been demonstrated by Cannon and several other observers, this factor must be looked upon as one of the causes of the poor growth of the trees in the grassed plot of the botanical area. Another important factor is the great reduction in the moisture content of the grassed plot during the dry season.

From a determination of the soil nitrate content of these plots, in every six inches, down to 1 ft. 6 in. (Table III), it was found that, during January to May, the soil nitrate content of the grassed and trenched plots varied between 0·3 and 0·4 parts nitric nitrogen per million soil, whereas in the cultivated plot, the figures varied between 4 and 5 parts per million soil. In June, immediately after the commencement of the monsoon, nitrification commenced in the grassed and trenched plots also and the nitrate contents in these were similar to that in the cultivated one. During the next three months (July to September), the nitrate in most cases moved downwards in all the three plots. After the close of the monsoon, while the grassed and trenched plot did not show any rise in the nitrate content beyond 0·4 parts nitric nitrogen per million soil, the cultivated one showed a gradual rise in the nitrate content, till in December it attained about 2 parts per million on the surface. Chart II shows the variation in the soil nitrate content of the three

[1] *Science*, N. S., **44**, p. 761, 1916.

CHART II.


December.
November
October
September
August
July
June
May
April
March
February
January
Nitric Nitrogen parts per million
Depth of Soil
Cultivated
Grassed

plots down to 1 ft. 6 in. from January to July and down to 3 ft. from August to December.

Table III.

Moisture and soil nitrate.

Months	Plot No. 1, grassed					
	Moisture %			Soil nitrate—nitrogen parts per million soil		
	0″–6″	6″–12″	12″–18″	0″–6″	6″–12″	12″–18″
January	2·60	4·92	3·68	0·310	0·400	0·236
February	1·68	3·96	2·94	0·307	0·237	0·319
March	1·64	2·85	2·63	0·383	0·311	0·233
April	3·52	1·32	1·68	0·235	0·305	0·307
May	1·09	1·76	1·06	0·609	0·307	0·228
June	13·63	11·15	1·84	1·265	4·884	0·615
July	13·70	15·90	11·50	0·452	0·466	0·439
August	19·31	21·16	19·65	0·688	0·607	0·593
September ..	14·28	15·21	14·14	0·456	0·555	0·455
October	15·79	14·76	12·55	0·373	0·367	0·356
November.. ..	11·56	11·58	9·29	0·351	0·351	0·340
December ..	6·88	8·11	7·68	0·411	0·418	0·416

Months	Plot No. 2, grassed but trenched					
	Moisture %			Soil nitrate—nitrogen parts per million soil		
	0″–6″	6″–12″	12″–18″	0″–6″	6″–12″	12″–18″
January	2·68	3·68	3·11	0·388	0·315	0·234
February	4·52	8·05	8·25	0·318	0·418	0·251
March	2·24	2·17	1·99	0·309	0·309	0·308
April	5·74	2·24	1·68	0·243	0·232	0·300
May	1·36	1·27	1·31	0·306	0·305	0·305
June	14·10	11·50	2·66	0·819	5·613	0·388
July	15·70	15·00	11·50	0·466	0·466	0·439
August	19·46	18·89	16·80	0·986	1·269	1·326
September ..	15·18	15·68	14·03	0·462	0·466	0·455
October	11·25	12·22	10·04	0·350	0·354	0·343
November.. ..	6·59	8·61	7·36	0·410	0·337	0·331
December ..	7·95	10·08	12·08	0·417	0·334	0·354

TABLE III—*concld.*

Moisture and soil nitrate.

Months	Plot No. 3, cultivated					
	Moisture %			Soil nitrate—nitrogen parts per million soil		
	0″–6″	6″–12″	12″–18″	0″–6″	6″–12″	12″–18″
January	6·74	9·92	9·20	4·102	0·600	0·428
February	6·27	9·93	8·63	4·239	0·343	0·421
March	4·49	7·68	8·83	4·614	1·828	0·760
April	4·39	5·81	5·39	5·087	0·324	0·403
May	3·67	8·49	7·63	2·760	0·924	0·332
June	22·05	15·56	10·15	0·616	5·762	1·204
July	14·30	15·70	14·90	0·452	0·652	0·745
August	17·34	16·69	14·27	0·477	0·477	0·365
September ..	12·43	14·66	15·97	0·533	0·459	0·468
October	9·34	12·51	11·67	0·749	0·513	0·610
November.. ..	7·76	9·77	11·11	0·750	0·513	..
December ..	7·99	12·81	13·31	1·840	0·447	0·450

Investigations into the moisture and soil nitrate contents of the grassed and cultivated plots, thus, further explained the effect of grass in retarding the plant growth. Apart from its effect in increasing the CO_2 content, which has a deleterious effect on the plant root, it depletes the soil so considerably of its moisture and nitrate content during dry weather, that normal growth is completely checked and plants sometimes die as well.

NOTES ON COTTON WILT IN THE SOUTHERN MARATHA COUNTRY.

BY

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THE wilting of cotton plants at some stage of their growth occurs all over the Southern Maratha Country, and is familiar to practically every cultivator. It is usually attributed either to insects or to the well known *Fusarium* wilt fungus residing in the soil, and carried by soil infection. The loss from wilting caused by insects is insignificant at present, but that generally ascribed to the fungus is very great, though its extent has never been accurately determined. Observations, moreover, indicate that this latter is extending, and the recent tendency of cultivators to grow cotton after cotton, without any rotation, seems favourable to its extension. It is possible, therefore, that the trouble will become far more serious in the future than it is at present. Steps are already in hand for the breeding of wilt-resistant types of Kumpta cotton at Dharwar, and the present note is intended to give some of the interesting results already obtained in that direction.

The literature on Indian cotton wilt is very scanty, and so far as the fungus which is said to be the immediate cause of it is considered, the article by Ajrekar and Bal in a recent number of this Journal[1] is almost the only piece of published information on the subject. The American publications regarding cotton wilt seem to deal with an entirely different fungus from that described by these as well as by other workers in this country. This seems

[1] *Agri. Jour. India*, XVI, p. 598.

likely, for American cotton, which is extensively grown in Dharwar, does not seem to suffer from this form of wilt even when grown in badly infested wilt areas, and the same is true for Buri, another cotton of American origin, in the Central Provinces. The same also seems true for all American cottons except Sea Island cotton, whose immunity is doubtful.

Variations in the susceptibility of Indian cottons.

On the Dharwar farm, which is extremely badly infested with wilt, a large number of different types of Indian cottons are grown, but all of them have, under the farm conditions, proved themselves susceptible to the disease. The susceptibility varies, however, very much with the different cottons. Attention was first called to this difference by the apparently abnormal susceptibility of Broach cotton, which suffered much more than others, but, later on, Goghari, another cotton, proved still worse. The relative susceptibility of different types when grown on adjoining plots affected with wilt, but not artificially infected, was as follows :—

Cotton variety	*Percentage of wilted plants*
1. Goghari (*Gossypium herbaceum*)	46
2. Broach (*Gossypium herbaceum*)	32
3. Jari (*Gossypium neglectum*)	23
4. Bani (*Gossypium indicum*)	15
5. Comilla (*Gossypium cernuum*)	12
6. Kumpta (the local cotton) (*Gossypium herbaceum*)	8

These figures only give a very rough idea of the relative degree of susceptibility as, in the absence of special thorough infection, the soil is not uniformly liable to cause the disease. It became necessary, therefore, to infect a small piece of land with the cotton wilt fungus specially raised for the purpose. The culture was mixed thoroughly with farmyard manure, and evenly spread over the plot, and on this a number of different strains of the local Kumpta

cotton with two other strains of supposed greater wilt resistance were grown. The percentage of attack was as follows :—

Strain or variety of cotton	*Percentage of wilted plants*
1. Kumpta (local mixed type)	22·3
2. Dharwar No. 3 (selection from local Kumpta) ..	55·1
3. Dharwar No. 4 (selection from Kumpta-Goghari cross)	55·4
4. Dharwar No. 5 (Ditto)	72·1
5. Rosea (a selection from *Gossypium neglectum*) ..	34·5
6. Wagale (a strain of Burmese cotton or *Gossypium obtusifolium*)	4·7

The difference in susceptibility is very striking. The strains of the cross between Goghari and Kumpta seem to retain the susceptibility of the latter. A pure strain isolated at Dharwar from the Burmese cotton known as Wagale proved almost entirely resistant. The experiment is interesting from another point of view. The local Kumpta cotton is a mixture of many strains, and of these some are very much more immune to wilt than others. The relative position of the local mixture and one of such selections is given above ; that of two others is as follows :—

Strain or variety of cotton	*Percentage of wilted plants*
1. Kumpta (local mixed type)	22·3
2. Dharwar No. 1 (selection from local Kumpta) ..	38·3
3. Dharwar No. 2 (Ditto)	5·6

The difference between these two strains is remarkable. Dharwar No. 1, though in every other way a desirable cotton, is evidently very susceptible to wilt, while Dharwar No. 2 is almost as resistant as any type tried.

We have thus two strains so immune to wilt disease that they may fairly form a basis for breeding with the object of getting a

much more resistant cotton than any in use at present. These are the strains of Wagale isolated at Dharwar, and our own selection from Kumpta which has been termed Dharwar No. 2.[1] Wagale is most unsuitable in every other way as a cotton for the Southern Maratha Country, but may well form the basis for a cross with Dharwar No. 1, which is otherwise the best of our improved types.

Effect of selection of pure strains.

For some years experiments have now been continued with the object of isolating resistant plants from plots composed of pure strains of cotton. Accordingly plants were selected, which were free from wilt, in a highly infected plot of Dharwar No. 1, and the seed from them grown. So far no appreciable progress has been made in this direction during the past three years and the progeny of the resistant plants seems equally susceptible with those from the ordinary seed of the strain.

Effect of locality on wilt resistance.

There are a number of types of cotton which have a reputation for wilt resistance in their own areas, and seeds of two of these having been obtained have been grown side by side with the other types in the specially infected plot. These two were Rozi, from Nadiad in Upper Gujarat, a type of *Gossypium obtusifolium*, and Bishnur Jari from Akola in the Central Provinces, a variety of *Gossypium neglectum*. They gave results as follows at Dharwar:—

Strain or variety of cotton	*Percentage of wilted plants*
Rozi..	82·0
Bishnur Jari	56·1

Both the cottons suffered very badly. As regards Bishnur Jari, there seems no doubt about its resistant nature in the Central

[1] Kottur. Kumpta Cotton and its Improvement. *Mem. Dept. Agri. India, Bot. Ser.*, X, p. 262.

Provinces. The writer has seen this cotton at Akola where it withstood the attack in a remarkable manner. But it failed to maintain its character at Dharwar, and this difference in its behaviour may be due to differences in the active exciting cause at the two places, or merely to differences in the environment under which it is grown. As to which of these is the reason of the differing behaviour, there is at present no evidence.

RICE GROWING IN THE KONKAN WITHOUT TRANSPLANTING.

BY

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THE growing of transplanted rice is a very laborious operation, and the difficulty and expense of transplanting is by far the most serious element in the production of the crop. It has, however, been generally supposed that by no other method can equal yields of rice be obtained as by transplanting, and though no definite experiments confirming this have been made, yet the supposition has been so constantly repeated that it is almost universally believed. If, however, the operation of transplanting could be eliminated, without loss of yield, a very great advantage would be obtained both to the grower and to the consumer, as in this case the price of rice would undoubtedly be reduced. With this in view I have conducted experiments at Bassein, for five successive years, in which the seeds were sown directly in the field by means of a regular field marker illustrated below, thus allowing of adequate weeding between the rows, and proper puddling at the same time.

The operations on the land by the writer's method of cultivation are as follows :—

(1) Ploughing of the land immediately after the previous rice crop.

(2) Re-ploughing of the land, and preparation for sowing in February or March.

(3) Sowing seeds before the rains in May or June by means of a marker allowing for square sowing.

(4) As soon as the seed has germinated and the lines of plants become visible, the field is weeded in both directions by a special weeder.

(5) When the water begins to stand in the field the weeder is again used to puddle the land.

(6) The number of plants in each hill is thinned as necessary and the plants obtained are used to fill any gaps in the field.

The ordinary method with transplanting is so well known that there is no need to describe it.

The actual records of the expenditure incurred in one experiment out of many are as follows :—

Sowing without transplanting.

	Cost per acre Rs.	A.	P.
(1) Ploughing on October 26th .. .. .. (2) Second ploughing on December 29th	1	8	0
(3) Marking and sowing on May 27th	2	13	0
Seed used 68 lb. per acre	2	0	0
(4) Rain fell on June 7th, and seed germinated by June 12th. Weedings were given on June 24th, and on July 10th, 11th and 12th	10	8	0
(5) Gaps were filled on July 12th	1	2	0
(6) Manure used	3	0	0

The total cost was thus Rs. 20-15-0 per acre, excluding the cost of harvesting which was the same in both cases. The yield obtained was

Grain (paddy)	2,820 lb. per acre.
Straw	5,288 ,, ,, ,,

Sowing with transplanting.

	Cost per acre Rs.	A.	P.
(1) Ploughing in October and December	1	8	0
(2) Preparing seed-bed (one-tenth acre) including ploughing, *rab* material and sowing	25	8	6
(3) Seed used (40 lb.) and weeding of seed-bed	1	6	0
(4) Preparing of field for transplanting	1	1	0
(5) Lifting and transplanting (July 13th and 14th) ..	9	8	0
(6) Weeding by hand (August 13th)	2	9	0

The total cost is therefore Rs. 41-8-6 per acre, excluding, as before, the cost of harvesting. The yield obtained was :—

Grain (paddy)	2,610 lb. per acre.
Straw	4,252 ,, ,, ,,

The results obtained in this experiment, which is merely representative of a number of experiments which have been done at

Bassein, at Alibag, and in cultivators' fields, would indicate considerable promise in the direction of growing rice without transplanting in the Konkan. They are being followed up and more complete results will shortly be available.

The special implements I use in the method described are two :—

1. *Field marker and planter* (Fig. 1). This is a wooden roller with a circumference of ten to twelve inches, in which square holes

FIG. 1. Field marker and planter.

are made to take pointed wooden pegs seven inches in length. The arrangement will be clearly seen in the illustration. The implement is rolled in the manner shown, leaving holes in which the seeds can be sown regularly, just as in the ordinary process of dibbling; only much more quickly. There is no difficulty in joining two or three rollers together (each being six feet long) and so sowing a breadth of twelve or eighteen feet at one time.

2. *Weeder* (Fig. 2). This is a wooden implement very similar in appearance to a light country plough (see right hand

side of the figure). It consists of a wooden pole about four feet long, having one end fitted with a cross piece projecting six inches on each side to serve as a handle for pulling, and the other attached to a handle, and a little over three feet long, fitted at the base with a short leg ten inches long, which forms the working part in the

FIG. 2. Weeder.

soil. The two sections of the implement are strengthened with cross-stays where necessary. The base section is fitted with an adjustable and reversible blade. In this form it requires two men to work it as shown, one pulling and the other pushing in the paddle between the rows of rice.

This weeder is also made to be used by a single man, and then consists of a wooden pole about four feet long, with the steel blade fixed at one end and a handle at the other, as shown on the left of the illustration. This is worked alternately backward and forward by the man using it.

Selected Articles

THE DEVELOPMENT OF AGRICULTURE IN INDIA.*

BY

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AGRICULTURE is admittedly our largest industry in India and furnishes practically all the material for the food and clothing of the people as a whole as well as raw materials for the larger part of our manufacturing industries; over the greater part of India it is in a backward state at present and therefore offers great scope for development on scientific lines. The value of the land, buildings, stock, implements, etc., which form the capital of the landholders of this country, must run into thousands of crores of rupees: the value of that could almost certainly be doubled by the application of science to practice. The scope for improvement is so great that the cost to Government of maintaining an efficient Department of Agriculture should be insignificant as compared with the value of the results which such a department would in course of time produce. Rapid progress will necessarily be slow owing to the apathy and ignorance of the people themselves. It is the bounden duty of Government therefore to provide the driving power; in no other way can it be provided. In India an intelligent appreciation of the value of research and of scientific methods hardly exists outside Government departments; very few of our public men who voice the sentiments of the people are personally interested in the development of agriculture, and our practical agriculturists are not sufficiently well educated to be able to express their views clearly, or to

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give a scientific department the backing it requires and deserves. India is placed at a disadvantage in this respect as compared with England, for example, with its large number of up-to-date "gentlemen" farmers, many of whom have studied the theory and practice of scientific agriculture at Universities and Agricultural Colleges. These farmers themselves conduct experiments with the assistance of the large staff of scientific advisers employed by the Ministry of Agriculture, the Universities and Colleges; they keep in touch with every new development in agriculture by subscribing for scientific periodicals, and play an important part in moulding the policy of Government. Living as they do in a scientific atmosphere, they appreciate the value of science and give the scientist the backing he needs.

The application of science.

The standard of cultivation in India to-day closely resembles that which obtained in England two centuries ago, when the wooden plough, since relegated to the museums as a relic of the past, was the tillage implement in common use. Such land as was under cultivation in England at that time gave very poor yields, and for want of efficient implements and draught power very large areas were never cropped. The agricultural unit in England at this time was the village with its scattered holdings, common grazing grounds, half starved cattle, and poor crops resulting from bad cultivation—all of which are characteristic of most parts of India at the present day. Wars and more especially the Napoleonic wars, the rapid development of manufacturing industries in urban centres, the consequent increase in the urban population and the decrease in the population of rural areas all helped to force up wages and the cost of farm produce. High prices, coupled with a rise in the cost of labour, stimulated the use of labour-saving appliances and the production of larger acreage yields; and the open field system of scattered holdings with its bad cultivation which resulted therefrom gave way slowly before economic pressure. In England the leading "gentlemen" farmers were the first to adopt the more intensive methods of farming demanded by the times. Holdings were consolidated and

fenced, and the cultivation of turnips, clover and other new crops which were to revolutionize farming was taken up on a large scale. There was as yet no science of agriculture which could be applied to the solution of its manifold problems. Men like Jethro Tull, Bekewell, Lord Townsend and Young, though not themselves scientists in our sense of the term, possessed the scientific habit of mind which they brought to bear on the agricultural problems of the day, and thus prepared the way for scientists who about the middle of the nineteenth century did so much for the development of English agriculture. As a result of the war of 1914–18 scientific enquiry in all branches of agriculture has been stimulated afresh in England. Statesmen and the public generally now realize the paramount importance of scientific investigation and of providing for the endowment of work connected with the development of agriculture on a scale commensurate with its great importance. They see, as they never did before, that the countries which have made the greatest progress and which obtain from the soil the highest return are those which have developed their research institutions.

An economic revolution.

The introduction of improved implements and machinery, of better seed and cattle and of manures and crop rotations which followed in the wake of scientific investigation revolutionized agriculture in the West, and has in about a century and a half enabled the English farmer to double the outturn of his crops, to drain and bring under cultivation large areas of waste land, to improve his methods of cultivation generally, and to make much larger profits. The increased productiveness of the land effected was all in the interests not only of the cultivator, but of the average citizen, helping as it did to keep down the cost of living at a time when our population was fast increasing. It was in the interests of the nation, too, in enabling it to hold its position in the markets of the world; but for the development of agriculture it would have been impossible for England to feed the hundreds of thousands of urban workers employed in her factories, and she could never have developed her

great manufacturing industries. If India desires to develop her main industry—agriculture—it can be done in the same way as it has been and still is being done in England and other advanced countries, namely, by employing highly qualified investigators to show the way, and by disseminating the results of their work among the cultivators.

History repeats itself; the economic conditions which obtain in India to-day resemble in many respects those which led to the development of more intensive farming in England in the eighteenth century. The price of farm produce has risen very much: industries other than agriculture are drawing labourers from rural to manufacturing centres, and there has been a general rise in wages. If he is to take full advantage of the new situation thus created, the landholder in this country will have to follow the example of the English farmer by adopting more intensive methods of cultivation involving the use of labour-saving machinery, of manures, and of better methods of cultivation generally. There are many indications that he is beginning to do so, the pity is that he is not as yet sufficiently well educated to take much part in moulding the policy of his Government. His supposed views are generally represented by men who live in towns and who are not practical agriculturists. This class of politician has within the last two years somewhat weakened the driving power of the Executive Government and progress is thereby being retarded.

The landholder in this, country unlike the English farmer of a century and a half ago, is in the fortunate position of having at his back a body of agricultural scientists who have, by research and experiment, produced results which should be of the greatest value if applied. Much has already been done to improve the cattle and the staple crops of the country by selection and hybridization, and the financial results therefrom have been most striking. To take but one example, namely cotton, the area now being sown in India every year with improved varieties probably exceeds 2,000,000 acres, and the increased profits therefrom, calculated on the basis of an increase of Rs. 10 per acre, must be somewhere in the neighbourhood of two crores of rupees annually. There

is no reason, however, why the increased profit on the cultivation of this crop should not be raised to twenty-three crores of rupees a year; for the total area under cotton is over 23,000,000 acres. In one province alone, namely, the Central Provinces, the introduction of a selected cotton is reckoned to have increased the annual value of the cotton crop by at least 70 lakhs of rupees which covers the annual expenditure on the working of the Department of Agriculture seven times over. For the improvement of other important crops, such as rice, wheat, *juar* (*Sorghum vulgare*), oil seeds and jute, there is also great scope for improvement, and much has already been done in that direction. It is no exaggeration to say that the value of crops in this country could be increased by hundreds of crores, by merely substituting improved strains of seed for the inferior low-yielding varieties at present grown.

Cattle-breeding.

In India where the bullock is the draught animal in common use and where milk products are common articles in the dietary of the people, cattle-breeding is of enormous importance. Poor draught cattle result in bad cultivation; bad cultivation results in poor outturns of grain for the cultivator and of fodder for his cattle; this again results in an impoverished cultivator and in weak and therefore inefficient draught bullocks. How to break this vicious circle is one of the most difficult problems facing the scientific investigator and Indian farmer to-day; for the standard of cultivation possible is largely dependent on the quality of the draught bullocks available. The introduction of improved implements on a large scale would be practicable if there were bullocks sufficiently strong to work them. The position, however, is by no means hopeless. Cattle in India to-day are probably but little, if any, inferior to those which were found in England in the middle of the eighteenth century. By better breeding and feeding English breeds have since that time been improved out of all resemblance to their progenitors. The improved breeds evolved have gained a world-wide fame, and England has become the world's principal stud farm. In the middle of the eighteenth century we read that cows

in England were such poor milkers that they did not produce enough milk to feed their calves, and that an average cow could be purchased for £3 or Rs. 45 in Indian money. By selection and cross-breeding, cows of some of our English breeds now yield 40 seers of milk daily and are worth at least Rs. 750. Most cows of Indian breeds are such poor milkers that it does not pay to keep them for dairy purposes; the average cow when in full milk seldom gives more than 6 lb. of milk per day. By selection and crossing the quality of breeds both for milk and draught purposes has, on Government farms, been greatly improved, and what is being done to-day on Government farms will be done in 20 years or less by enterprising cattle-owners in this country. A herd of Montgomery cows on the farm of the Pusa Research Institute has within 10 years been improved to such an extent by selection that their average daily milk yield per cow has increased from $5\frac{1}{2}$ to 9 lb. per day, including dry periods during which no milk was given. This improvement should add at least 40 rupees to the value of each animal: but the improvement effected by cross-breeding is still more striking, the average yield from the Pusa Ayrshire-Montgomery crosses on the same basis of calculation being 15 lb. per day. The improvement effected on some of the breeding farms managed by Provincial Governments where draught breeds are kept is also worthy of note. The animals bred thereon are much larger and stronger than those reared in villages under existing conditions, and they are probably worth at least Rs. 40 more per head. Taking into account the fact that there are about $14\frac{1}{2}$ crores of animals in India, it is evident that there is enormous scope for adding to their value by better breeding and feeding.

Agricultural implements.

The Indian cultivator is working at a great disadvantage owing to the inefficiency of his agricultural appliances. His tillage implements are so light and small that they do not kill out weeds effectively; nor can they be used for ploughing under weeds and other forms of leaf manure when that is necessary. Of all the implements in common use in India the country plough or *nagar*, as it is commonly

called, is perhaps the most inefficient. It may be described as a piece of wood shod with an iron point which constitutes the share. It is fitted with a wooden pole and is usually drawn by one pair of bullocks. Having no breast it stirs the soil without inverting it, and having no cutting parts it does not eradicate weeds. The argument advanced against the introduction of iron ploughs and other improved implements is that they are generally heavier to pull than those in common use, and are not, therefore, suitable for the draught cattle of this country. The improved implements are, however, appreciably lighter in draught as a rule than those which they are replacing. The M. S. N. plough so popular in rice tracts weighs 34 lb. and can be drawn by a pair of very small bullocks.

Ploughs of the Rajah and Punjab types which have found favour in the Gangetic valley are not too heavy for one pair of ordinary bullocks.

In black cotton soil tracts, improved iron ploughs have become very popular ; thousands are now being sold there every year and some cultivators have of late years taken to the system of ploughing land on hire with Turnwrest ploughs after completing their work on their own farms. Another plough, which has done exceptionally well in this tract, is the Sabul which is specially suitable for ploughing cotton land in the dry season. An important feature of the Sabul plough is that it is equipped with a share having a renewable and adjustable bar point made from a specially prepared high carbon steel. The plough weighs 145 lb. and does better work when drawn by two pairs of bullocks than the heavy *desi* plough which requires three pairs.

Landholders are beginning to realize that it pays to eradicate from their fields perennial weeds such as *dub* (*Cynodon dactylon*) and *kunda* (*Andropogon punctatum*) which in badly tilled fields compete year after year with their staple crops for the limited amount of moisture and plant food available in the soil. The loss in yield due to the growth of weeds in cultivated fields must in the aggregate be colossal, more especially in tracts where *kharif* crops are mainly grown. But even in *rabi* tracts, where wheat and gram are the principal staples, the loss in yield every year due to the low standard

of cultivation and to the perennial crop of weeds resulting therefrom is enormous. *Kans* grass (*Saccharum spontaneum*), one of the most obnoxious of these weeds, has got thoroughly established over large areas in Central India, the Central Provinces and Bundelkhand in the United Provinces. This weed has a stoloniferous root which branches freely at a depth of about 7 or 8 inches from the surface. It is found in the best wheat soils which retain moisture in the hot weather and many hundreds of thousands of acres of such land have gone out of cultivation in consequence. Much of this area has lain fallow since the famines of 1896 and 1900; but in addition to this fallow area, there are many hundreds of thousands of acres in which *kans* competes year after year with the wheat, gram and other *rabi* crops grown, the yields of which are thereby greatly reduced. After each famine the draught power of the village is reduced, for many bullocks die of partial starvation and the strength of the remainder is reduced owing to the same cause. For want of sufficient bullock power the weed gets the upper hand and the land is allowed to lie fallow thereafter. Such is the fate of the patient plodding tiller of the soil in India to-day where the bullock supplies the motive power. In a famine year unfortunately the quantity of food by the bullock required to produce the energy needed is not forthcoming. The Settlement Officer of Saugor District in the north of the Central Provinces says that the area under *kans* in that district alone amounted in 1916 to about 180,000 acres or 15 per cent. of the cropped area. We may take it that landholders in *kans*-infested tracts are losing at least Rs. 30 an acre annually by allowing any such land to lie fallow.

Tackling the weeds.

To reclaim *kans* land by means of the ordinary implements used in the villages is almost impossible, except when the weed is tackled in its early stages by more or less continuous ploughing, and even then it is extremely difficult to accomplish. Small areas of *kans* have been eradicated by means of both the Sabul and the Turn-wrest ploughs worked to a depth of 7 or 8 inches. With the inferior bullocks available in the wheat tract it is difficult, however, for

the ordinary cultivator to use these ploughs in the dry weather when the soil is dry and hard ; and *kans* cannot be killed by ploughing during the rains. The introduction of the motor tractor may perhaps solve the difficulty. The cost per acre of ploughing clean land with tractors is about Rs. 20, including interest and depreciation : in stiff soil badly infested with *kans* the indications are that the cost will be about Rs. 30. But even at Rs. 30 it will pay the owner very handsomely to have such land brought under cultivation, seeing that one crop should about cover the cost of reclamation. When tractors are used, the land can be ploughed in the dry weather in which case the roots of the weed are killed by being exposed to the sun and dry air.

From experiments already carried out it would appear that over 90 per cent. of the roots are killed by one ploughing. Enterprising landholders at times eradicate small areas of *kans* by manual labour, in which case the cost of hand digging amounts to Rs. 80 an acre. In a test carried out on the College Farm, Nagpur, it was found that when employed for eradicating *kans* a tractor did as much work per day as 16 pairs of bullocks, and as much as 288 men when employed in removing the roots by digging.

On the strength of information obtained from these and other experiments, the Government of the Central Provinces has agreed to give loans under the Land Improvement Loans Act to cultivators desirous of eradicating *kans* and other perennial weeds from their fields, and the Department of Agriculture is now working tractors lent by an enterprising Bombay firm ploughing weedy land for cultivators at a fixed acreage rate. Syndicates or private firms will, it is hoped, take up this important line of work in course of time. It requires no great stretch of imagination to understand the potential value of mechanical power if used for converting such fallow areas into productive land.

Use of tractors.

There is a good deal of controversy as to the respective merits of steam cable sets and motor tractors. Into this controversy I do not wish to enter ; suffice it to say that the former would probably

prove the more efficient for work in the *kans*-infested areas already referred to. Their initial cost is, on the other hand, so high that there is little chance of their being tested by Government in these days of financial stringency. The tractor is being tried because it is much less costly: it can, moreover, be used with advantage not only for ploughing and cultivating land, but for driving stationary machines such as cotton gins, pumps, flour mills and fodder cutters. As at present designed, the tractors tried are not sufficiently strong and fool-proof for Indian conditions, and much difficulty has been experienced in some provinces in keeping them in good running order. Workshops where repairs can be executed are few and very far between, and all the agents in this country have not yet realized the paramount importance of keeping a large supply of spares in stock. Still the fact remains that under specific conditions and with intelligent use the tractor is a farm-power unit of great possibilities in tracts where the draught power at present available is inadequate. There are on the market at the present time more than 50 makes of tractors varying to some extent in type. They may be roughly classified as wheeled types and caterpillar types.

Tractors of the caterpillar type are well suited for after-cultivation work; their weight is distributed over a much larger area than that of wheeled tractors, and they do not therefore pack the soil so much. They can for the same reason be worked on land which is too wet for wheeled tractors. Another advantage claimed for this type is that they are very suitable for work in small fields as they can be turned in a small space. For ploughing hard land there is little to choose between the two types; but it may be claimed for the wheeled types that there are no tracks to be renewed every second year or so, and that the cost of upkeep is, therefore, less. For stationary work both kinds are equally suitable. Both types suffer in the hands of careless drivers from over-heating and many break-downs are due to this cause alone; for it is extremely difficult at present to get in this country properly trained mechanics, and to put a tractor in the hands of a man of the cooly class, even after he has been trained to drive it, is to court disaster. This and other

difficulties will, however, gradually disappear with the advent of facilities for training mechanics.

The improvement of draught cattle, the introduction of better implements and the use of mechanical power will enable the cultivator to perform his tillage operation under optimum conditions; poor yields are often due in no small measure to the land being ploughed badly or too late. The wheat grower, for example, who harvests his crop in March spends weeks in treading out the grain under the feet of his bullocks and in separating it from the chaff. Given a good threshing machine and winnower, this work could be done in as many days. So much time is spent over each operation at present that ploughing for the next crop has often to be put off till the rains. Over a greater part of the wheat tract, the monsoon breaks about the middle of June, and in years of heavy and continuous rainfall the breaks are so short that the area ploughed before the close of the monsoon is small. With the abrupt cessation of the monsoon, the soil rapidly dries and becomes too hard for ploughing with the country plough. The seed has thus to be sown in a badly prepared seed-bed. Ploughing with improved ploughs in the hot weather has, in some parts of India, increased the yield very largely. Land ploughed before the rains break absorbs much more of the rainfall than unploughed land. Ploughing provides for the better aeration of the soil, too, and thereby stimulates bacterial action in the formation of nitrates. Ploughing thus done under optimum conditions provides for the succeeding *rabi* crop a store of moisture and nitrogen.

DEMAND FOR IMPROVED IMPLEMENTS.

The introduction of improved tillage implements has opened up a vista of great possibilities for the agriculture of this country. The efficiency of these implements is largely due to their having been designed by the trained engineers of certain firms working in collaboration with agricultural experts in India. Many of the improved ploughs thus introduced have met a felt want. Machines for harvesting crops, for cleaning grain and for chopping fodder have yet to be evolved. A reaping machine suited for cutting *juar*

would be a boon ; such a reaper should be high-geared and should have a short cut of from three to four feet. The fingers of the knife bar and the knife itself should be strong and the sheaf board long enough to support the stalks which are usually six or seven feet long and about three-quarters of an inch in diameter. For wheat mowers there is already a small demand which is likely to increase, as the cost of labour, more especially at harvest time, is rising.

For fodder cutters a fair demand already exists. In *juar*-growing tracts about one-fifth of the stalk is wasted when fed whole to cattle, as they refuse to eat the coarse ends unless they are cut into small pieces. The high price of these machines prevents all but well-to-do cultivators from buying them.

For winnowers, too, a demand already exists ; but the prices charged for imported machines are so high that cultivators cannot afford to purchase them. The winnowers made in India by village carpenters are less expensive, but at the same time less durable. The sale of these inferior country-made imitations of imported machines is no doubt detrimental to the trade in agricultural machinery generally ; but the solution of the difficulty is in the hands of the big manufacturer. To create a demand, they must be prepared to supply India with her requirements at reasonable prices.

The method in vogue in India of treading out the corn with the muzzled ox is a slow and primitive process. The need of improved machinery is becoming more evident every year. Threshers driven by oil engines are now being used on Government farms and will no doubt find favour among cultivators in course of time. One objection to their use is that they do not break up the straw into small pieces. This objection, however, is not a very serious one, perhaps, seeing that this can be done later by means of a separate fodder cutter.

The demand for improved iron cane mills of the three-roller type and capable of being worked by a pair of bullocks is very great. Most of these bullock-driven mills give about 10 per cent. more juice than the *desi* mill which they are fast replacing. Their introduction must be adding lakhs of rupees every year to the profits

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of cane cultivation in India; for there are now hundreds of thousands of them in use. It is a pity that no firm in England has specialized in the manufacture of bullock-driven cane mills; for the workmanship of those turned out in India is generally poor. The mills turned out by the Nahan foundry in the Punjab are an exception to the rule, and the demand for the mills made there exceeds the supply. A small all-iron cane mill capable of crushing half a ton of cane per day when worked by a pair of bullocks would find a ready market in this country if offered for sale at Rs. 200 or less.

Fencing against animals.

Wild and domesticated animals do a great deal of damage to crops in India. Wire fencing is used on a small scale only, and the result is that stray cattle in the villages as well as antelope, wild pigs, jackals, etc., rob the cultivator of the fruits of his labour. Of the wild animals to be considered in this case, the wild pig is perhaps the most destructive. Being a nocturnal feeder he lies hidden during the day in the jungle or grass-covered wastes which are often many miles from the crops, on which he feeds. The cultivator sometimes constructs a fence of thorns or bamboos round the field he wishes to protect, but as all such fences are more or less inefficient, it is customary for him to keep also a watcher in the fenced fields at night. The wild yells of this watcher on the approach of "grunters" are generally sufficient to scare them away; but, at times, Homer-like he nods and the pigs break in and steal. In the morning the owner of the field finds that his crop has been very materially damaged and his profits for the year thereby reduced. Patent pig-proof woven wire fencing has been introduced in some provinces with good results. The demand for this type of fencing wire is likely to increase very largely.

The whole field of Indian agriculture still bristles with unsolved problems; but in a short article it is possible to deal only with a few of the outstanding ones. The activities of Provincial Departments of Agriculture extend over a wide field and improvements are being introduced which are both adding to the wealth of the cultivator and fitting him for further progress. The great task of

reconstruction is well worth all the brains and energy which can be put into it; for on the development of agriculture depends not only the prosperity of India's many millions of agriculturists, but to a great extent the lot of those engaged in other industries, too. Increased crop production will help to banish famine and poverty from the land and to bring us nearer the realization of our desire, namely, to make India "a garden ringing with cheerful and contented life, with smiling fields and food in plenty."

METHODS ADOPTED IN AUSTRALIA FOR DISINFECTING COTTON-SEED.*

For some time past the Victorian Department of Agriculture, acting through the Government Plant Pathologist, Mr. C. C. Brittlebank, and Mr. D. B. Adam, B.Ag.Sc., has been engaged upon a series of experiments, having for their object the cleansing of cotton-seed from parasitic attachments tending to promote disease. In this country, where a resolute endeavour is now being made for the cultivation of cotton on a commercial scale, it is thought to be of the greatest importance to prevent the planting of contaminated seed in order to ensure healthy and profitable stock. Doubtless the effort is beset with much difficulty. Whereas in the laboratory it may be comparatively easy to strip the seed operated on from every trace of infection, to do so on the bulk of seed used in the ordinary process of cotton planting would be a troublesome and expensive task. From the report of Messrs. Brittlebank and Adam the following statement is taken.

The cotton plant, *Gossypium* sp., is liable to a variety of diseases. Some are caused by fungi, the spores of which are carried on the lint remaining on the seed after ginning. Black rot, or cotton wilt, caused by the fungus *Fusarium vasinfectum* E. F. S. and anthracnose of the boll and stem caused by the fungus *Glomerella gossypii* Edg. are examples of two serious diseases which are spread by this method. Neither of these diseases has been reported as occurring in Australia. There, however, is a possibility of their being found in Queensland, where cotton has been grown for about 50 years. As no effort to prevent the introduction of disease in the original seed samples was made, that State must be considered a possible source of infection. All seed brought from there should

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* Reprinted from *Tex. Recorder*, XLI, No. 486.

therefore, be subjected to the same disinfection and treatment as any imported from overseas. On account of the dryness of the adhering lint, it is difficult to effectively soak the usual sample of cotton-seed in any disinfectant. It is necessary to remove the lint. The concentrated sulphuric acid method of treatment is an efficient and cheap way of delinting cotton-seed. The seed is placed in a wooden or earthenware vessel, and then covered with commercial sulphuric acid for from ten to fifteen minutes, being stirred constantly with a wooden ladle. The seed can be removed in an earthenware vessel with a sieve bottom. The same sulphuric acid may be used for treating several lots of seeds. The treated seed is then washed in running water for 20 minutes and allowed to drain. For complete disinfection the seeds may afterwards be placed in corrosive sublimate (1—1,000) for 15 minutes, and at the end of that time allowed to dry. Experiments in the use of this process have been made in the laboratory of the Department of Agriculture in Victoria. Some have been designed to test the effect of the treatment on the germination of the seed and the condition of the young plants. Other experiments have been carried out to test the effect of immersion in sulphuric acid for varying periods of time.

The effect on germination.

Two samples of 100 seeds each were taken. One was treated for 15 minutes with sulphuric acid and then washed for 20 minutes and germinated. The other sample was not treated. Of the treated seed 88 per cent. has germinated in three days, and in four days 93 per cent., which was the total germination. The growth was clean and vigorous. Of the untreated seed 86 per cent. germinated in four days, and 90 per cent. in six days, which also was the total germination. The growth of these plants was not as vigorous as that of those from the treated seed. Many treated seeds were grown in pots. Of the plants to be used for inoculation experiments none failed to germinate; all gave clean, healthy, vigorous plants. Some of the plants grown from untreated seed were sickly and apparently affected with disease. A suspension obtained by

soaking untreated seed was used to inoculate agar plates. Among the numerous fungi found, a *Fusarium* was isolated. This was used for inoculation experiments with results, details of which are given below :—

(*a*) Some clean cotton-seeds were planted. Eleven days after they showed above ground, they were infected with spores from an agar culture placed on the soil around each plant. In four days all the plants were affected.

(*b*) Soil was sterilized in an autoclave at 110°C. for two hours. Cotton-seed was treated with sulphuric acid for 15 minutes, washed for 20 minutes, and sown in four pots with this sterilized soil. Five seeds were sown in each pot.

Treatment	Number germinating	REMARKS
(*a*) 1. Seeds infected from culture ..	..	....
2. " " " " ..	2	Spores formed on primary leaves.
(*b*) 3. Seeds infected with spores ..	1	....
4. " " " " ..	1	....

The exact species of *Fusarium* has not been definitely fixed. In acute cases it has entirely prevented the germination of the seed.

THE EFFECT OF VARYING THE TIME OF IMMERSION IN SULPHURIC ACID.

Small bottles, each containing 100 seeds with sufficient sulphuric acid to cover them, were used. After the period of immersion and washing, the seeds were placed in damp blotting paper and incubated at 75°F. The first examination took place four days

afterwards, the final examination two days later with the following results :—

Time of immersion	First germination	Final germination	Remarks
Minutes	Percentage	Percentage	
0	86	90	The plants were more vigorous and cleaner than those from untreated seed.
15	88	93	
20	86	90	
25	84	87	
30	92	94	
35	80	85	
40	84	86	
45	92	95	
60	83	86	
75	88	91	
90	91	93	
120	88	89	
240	90	94	

From this table it may be seen that prolonged immersion of four hours did not affect the germinating capacity. Some seedlings from treated seed have been grown in pots and have given perfectly healthy plants and bolls. To test whether seeds could be killed with sulphuric acid, some seeds were left in concentrated acid for twenty and forty hours respectively, and afterwards washed. Germinations of 91 and even 92 per cent. were obtained. With the former, a good clean, healthy growth resulted. In the second case, many of the young plants were malformed. The sulphuric acid had decomposed the pericarp, and had begun to attack the cotyledons, or subsequent primary leaves.

It is doubtful whether any of these plants would have grown much further than the seedling stage. From the data given, there seems to be little danger from too long immersion within reasonable limits. It was thought to be advisable to test the effect of treating

seed with sulphuric acid for varying periods, then washing, drying, and allowing to stand for a week, and this was done. The results obtained are given below. Seeds germinated at 75°F.

Time immersed	Germination
Minutes	Percentage
15 ..	94
30 ..	92
45 ..	94
60 ..	90
Check ..	90

This shows that a delay of one week after immersion and before planting has no effect on germination. When sulphuric acid and water are mixed great heat is rapidly developed. Under some conditions this may do so with explosive activity, hence sulphuric acid must always be used with care. After treatment with sulphuric acid and subsequent draining, the seed should be placed in a large volume of running water. An experiment was conducted by adding a small quantity of water to treated seed; the temperature rose to 180°F., but with the addition of more water it soon fell. Subsequent experiments showed that seed held in hot water at 180°F. for five minutes failed absolutely to germinate. At 160°F. for five minutes, of two samples, 46 and 41 per cent., respectively, germinated. The necessity for care in handling sulphuric acid cannot be too strongly impressed upon those unacquainted with its strength. If it comes in contact with the hands it will burn them, and any splashed on clothes will damage them.

Summary.

(1) The spores of many serious diseases are borne in the lint attached to the seed.

(2) The lint is most conveniently removed by sulphuric acid.

(3) The necessity for treatment of all imported samples is shown by the isolation of a pathogenic *Fusarium* from an imported cotton-seed sample. Its pathogenicity has been demonstrated.

(4) Immersion up to four hours has no effect on the capability of the seed to germinate.

(5) Finally, the seed after immersion in sulphuric acid should be washed in a large volume of running water.

The report of the Government pathologist and his collaborator ends at this point.

One of the most striking exhibitions seen during the course of these experiments was the strong vitality of cotton-seed under circumstances that might have been presumed to be completely destructive. On the other hand, it was proved that the seed is very sensitive to a comparatively small increase of temperature and is injured by it.

The purification of cotton-seed as a provision against the spread of disease is unquestionably a work of necessity and importance, and to carry it out on a scale commensurate with the planting of large areas seems to invite the attention of the mechanical engineer in co-operation with the chemist and pathologist.

THE IRRIGATION OF THE SUGARCANE IN HAWAII.*

Irrigation in the sugarcane fields in the Hawaiian Islands is not confined to those parts on the western side where the rainfall is insufficient for the growth of the cane to maturity, but extends throughout the planted area, especially in Kauai, Oahu and Maui. Although the local practice of irrigation has turned out to be a very costly proceeding when compared with that in other parts of the world, it is found to be a very paying proposition, and the plantations are not only concerned with the tapping of rivers and the storage of the rainfall and bringing these supplies on to their fields, but this supply is supplemented by immense pumping plants by which the underground water supplies are brought to the surface and similarly utilized. And so convinced are the planters of the profitableness of this line of development that, besides the investment of large sums of money in canals and pumps, the labour allocated to the leading of the water on to the fields has become the dominant item in the balance sheet of those estates which use this means of increasing their outturn of sugar. In addition to all this, they are spending large sums of money on reafforestation, in order to keep up the supplies of soil water and to utilize to the best advantage the natural rainfall of these favoured islands.

A full study of the whole subject has been made by W. P. Alexander and is presented in a thesis " in partial fulfilment of the requirements for the degree of Master of Science in the University of Hawaii," and this has now been published by the Hawaiian Sugar Planters' Association in pamphlet form.[1] This pamphlet deals with the whole accumulated literature of the subject (73 papers) and is compressed into 109 pages, with 63 illustrations and numerous tables. As the author has himself done much useful research on the subject and leaves no part of the field untouched, the paper is

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* Reprinted from *Int. Sug. Jour.*, XXV, pp. 401–408.

[1] " The Irrigation of Sugarcane in Hawaii." Experiment Station of the Hawaiian Sugar Planters' Association, Honolulu, 1923.

an extremely valuable one. It is well and clearly written, although in parts the desire for compression has made it a little difficult to follow, and one would in some places have wished for a more generous treatment as regards explanatory remarks.

The thesis commences with a brief introduction of a general and historical character (10 pages), and this is followed by a detailed review of irrigation practices, continuing with summaries of the various lines of research which have been followed by the different workers in the field from the commencement, and concluding with a detailed local bibliography of the subject. To give an idea of the treatment and the relative development of the different sections, these are given below with the number of pages in brackets devoted to each : After the introduction follows a brief statement of the standard method of distribution of water in the field (2), and an important discussion of the application of water, including the most recent variations from this method (33). Then the following are dealt with in briefer summaries: Duty of water (5), Conservation of water (13), Soil moisture studies (6), Economical distribution and optimum application (9), Time element in irrigation practice (7), Saline irrigation (2), and Application of fertilizer in irrigation water (2). Owing to the great mass of material brought together, it is somewhat difficult to review the paper, but the present article endeavours to lay out before our readers the salient features of this great problem, and this is to a certain extent rendered more easy by the recent publication in this Journal[1] of a description of the more recent advances in economizing the labour involved.

For the production of profitable crops of sugarcane, over 50 per cent. of the fields in the Hawaiian Islands are almost entirely dependent on irrigation, and the tonnage from this proportion of the area under cane exceeds two-thirds of the total sugar output. This will be readily understood from the subjoined figures of the irrigated and unirrigated areas under cane in the four sugarcane growing islands. In Kauai 40,036 acres are devoted to sugarcane cultivation, 95·66 per cent. of which are irrigated : the figures for

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[1] *Int. Sug. Jour.*, XXV, pp. 180–184.

Oahu are 40,352 and 98·25, and for Maui 50,906 and 89·52; while, on the other hand, there are 93,126 acres of cane land in Hawaii, only 6·97 per cent. of which are dependent on artificial watering.

Irrigation has been used in the local sugar industry from its start. The first project was carried out in Maui in 1878, when water was diverted from the rainy eastern slopes seventeen miles across to the arid western side: this was completed at a cost of $80,000. It was immediately followed by a large project carried out by the Hawaiian Commercial and Sugar Company for the irrigation of the central Maui plains, and from this beginning an irrigation system has developed which has cost some $4,000,000, the latest addition being the great Wailoa ditch delivering 140 millions of gallons at an elevation of 1,100 ft. and costing $1,500,000; this aqueduct the author regards as the largest in the world. An enumeration follows of the chief projects for the storage and delivery of rainfall water on similar lines throughout the islands, mountains being tunnelled, valleys bridged and syphons erected for the negotiating of the irregularities of the mountainous country to be traversed. Besides these projects, steps have been taken to tap underground water supplies which would otherwise be wasted, and a number of immense pumping stations have been installed, the machinery alone of which has cost some $6,000,000. The electrification of the latter has recently been undertaken as it has been proved to be by far the most economical method of lifting the water. Altogether, the 24 plantations on which irrigation is employed have invested something like $17,000,000, while close on 100,000 acres of forest land are owned and set apart for the conservation of the water supplies.

It is estimated that in Oahu 2,500 millions of gallons of water are pumped every month from artesian sources for the sugar plantations. For the maintenance of this supply, assuming that there are 300 days in the year used for pumping, it is necessary for 25,000 millions of gallons to enter the underground system every year. The proportion of watershed is considered to be twice that of the cane area served, and thus 100 inches of rainfall a year must find its way from the forests into the subsoil. The

conservation and replanting of the remnant of the natural forests of the islands, which have been deplorably devastated for many years past, has thus become a matter of supreme importance to the planters, and is, in fact, receiving marked attention from the Hawaiian Sugar Planters' Association, which is working hand in hand with the Government and the individual planters themselves.

The cost of irrigation per acre and per ton of sugar is set forth for the crop of 1914 in a table, in which the averages work out as follows: cost per acre \$67·91, per ton cane \$1·42, percentage of labour employed on irrigation to total labour in getting the crop to the mill 62·97. These figures are then compared with those obtained from Porto Rico and Cuba, although irrigation in the latter island is to be regarded as in a purely experimental stage. In 18 Porto Rican plantations the cost of irrigation per acre is given as \$15·76 and that per ton of cane \$0·63, while the figures for the four Cuban estates are \$2·18 and \$0·08 respectively. From these details it is obvious that in Hawaii the profitable production of sugar is subordinated to the intelligent use of irrigation. With this idea in his mind, the author of the thesis aims at a stimulation of research in this direction and devotes his attention chiefly to the means by which the heavy costs of applying the water to the fields may be reduced to a minimum.

The standard irrigation practice in Hawaii is concisely described by means of a diagram here reproduced (Fig. 1). The elements thereof, once the water has been brought to the plantation, consist of a series of water channels of different calibre and arrangement. These are, in succession, as follows: main supply ditches, running along the higher contour lines and therefore more or less level; straight ditches more or less at right angles to them, that is, running down the slope; level ditches again running along the contour lines and 200–300 ft. apart; watercourses, small improvised channels down the slope leading the water to the furrows, the latter lying more or less across the slope of the land, 30 to 35 ft. long and about 5 ft. apart. The adaptability of this scheme to all kinds of topography has made its practice almost universal. But, as will be seen, there are numerous small deviations according to the conditions.

The method of supplying the water does not greatly vary, but the actual practice depends on a great number of special local

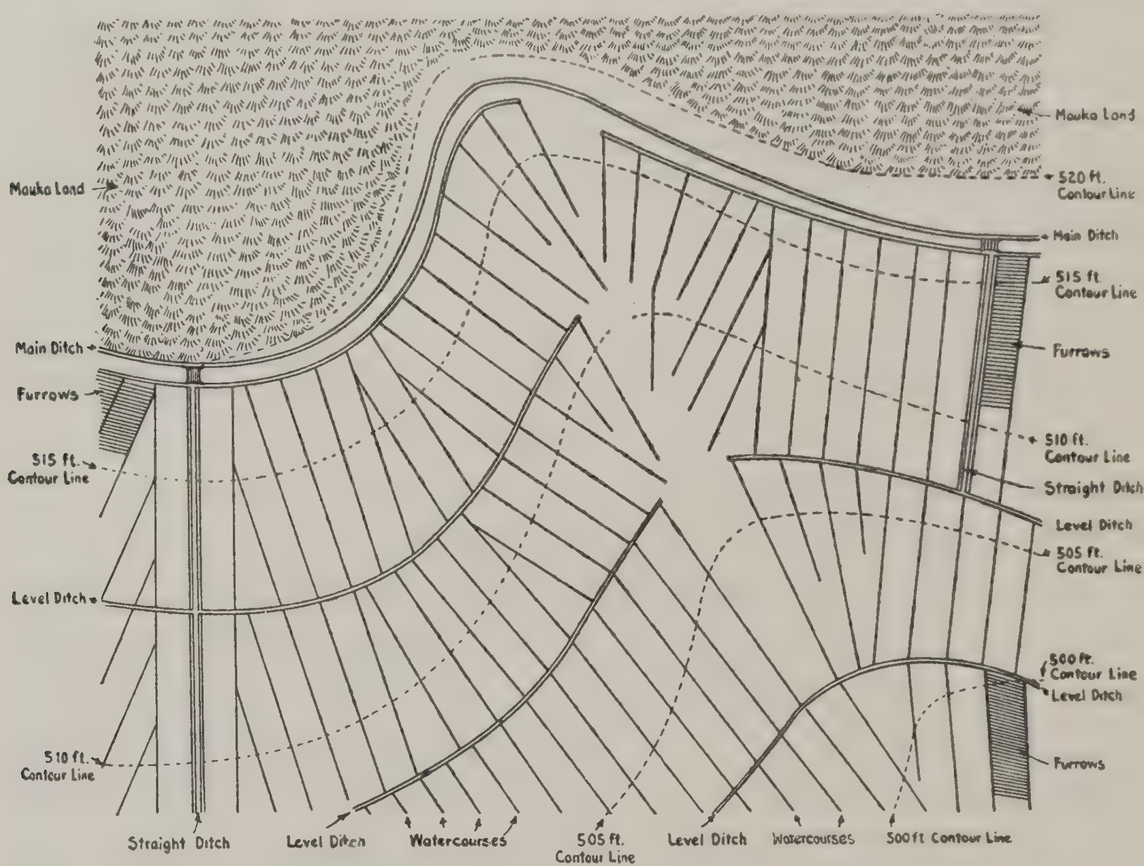

FIG. 1. Diagram of the Hawaiian furrow system.

circumstances. Such are the nature of the supply, whether steady or fluctuating, and its sufficiency for maintaining the supply all the year round; the occurrence of freshets with only a limited water storage capacity; whether the cost of pumping as supplemental is found to be profitable; the necessity of over-irrigation because of salinity; the labour available and its skill and the nature of the supervision required; the texture of the soil, whether light or heavy, rocky or smooth; the presence of coral below, retention of moisture and drainage facility; the condition of the field, whether the furrows are shallow or deep, and the condition of the watercourses; the slope and regularity of the contour; the kind of cane grown, its habit, whether erect or recumbent, light or heavy yielding, the amount of trash produced, whether plant cane or ratoons, hilled or unhilled; the periods of irrigation and the relation of these to weeds, the possibility of applying fertilizers in the irrigation water, and so forth.

In the standard practice every row is irrigated separately from one side only of a watercourse (Fig. 2), and this is considered the best method by the managers of the largest and most successful plantations. The two-way system, as described by Maxwell, gives water to the furrows from both sides of a watercourse at the same time ; it is said to be economical of water, but even land is required. Every other row irrigation is an emergency method for hilled-up cane, the alternate rows being filled up with trash ; it saves time and weeding and is a big help when water is scarce. Percolation is found to be sufficient to keep the soil moist, but the ultimate yield of canes is deficient.

Cutting lines is the name given to another method, in which one outlet of the watercourse irrigates a number of furrows in succession, as follows : When the water reaches the end of the first furrow, the ridge between it and the next below is cut across, so that the water enters the latter and flows back again towards the watercourse, and by repeating the operation a number of furrows can be dealt with by one opening from the watercourse. In one form or another this deviation from the standard is used by 16 out of 26 plantations, but only after the first two or three months. It is useful for holding back the water of freshets with little natural storage capacity, or for flooding after a dry spell when heavy rains occur. The first furrow, of course, gets too much water and the method is inapplicable to porous soils. When the water is short, single line irrigation is reverted to.

The Ewa or Renton system (Fig. 3) is a combination of the two-way and cutting line systems and saves labour, as well as land, because half the usual number of watercourses with their banks are available for cane growth. In 1914 by the old method one man was able to irrigate 8·29 acres in a day, but in 1916 by this system a single labourer was found to be able to attend to 13·35 acres. The system has been in use on the Ewa plantation for 20 years, but it is only practised on three plantations. The chief objection is that lands are usually too steep and that too much soil would be washed away, but it has much to recommend it in the saving of labour.

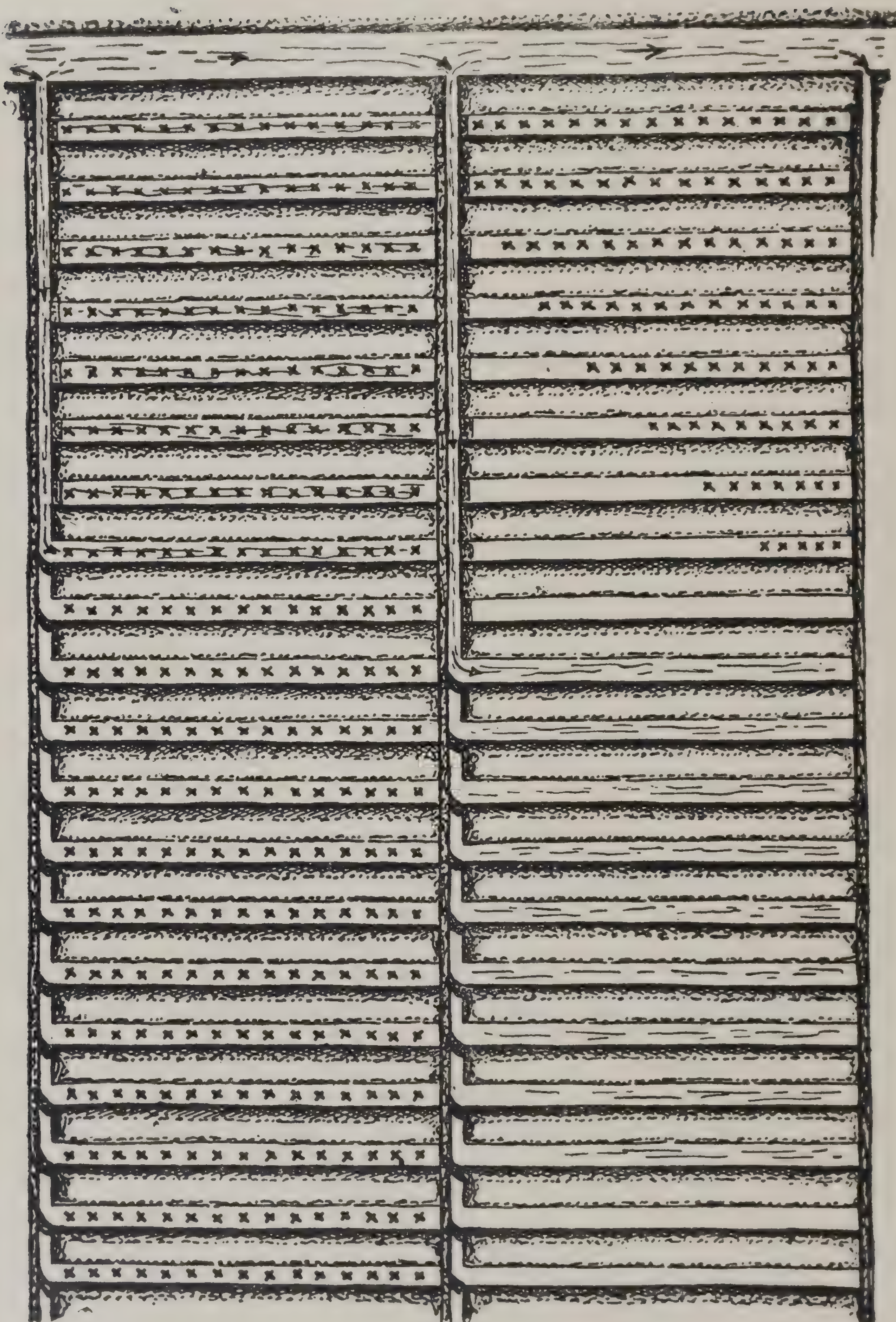

Fig. 2. Hawaiian furrow system.

An enlarged sketch of the actual layout from level ditch to furrow, showing the arrangement of watercourses and furrows when each row of 35 ft. is irrigated separately. There are between 40 and 70 furrows to one watercourse, depending on the field and plantation practice. The crosses signify the position of the cane plants in the furrows.

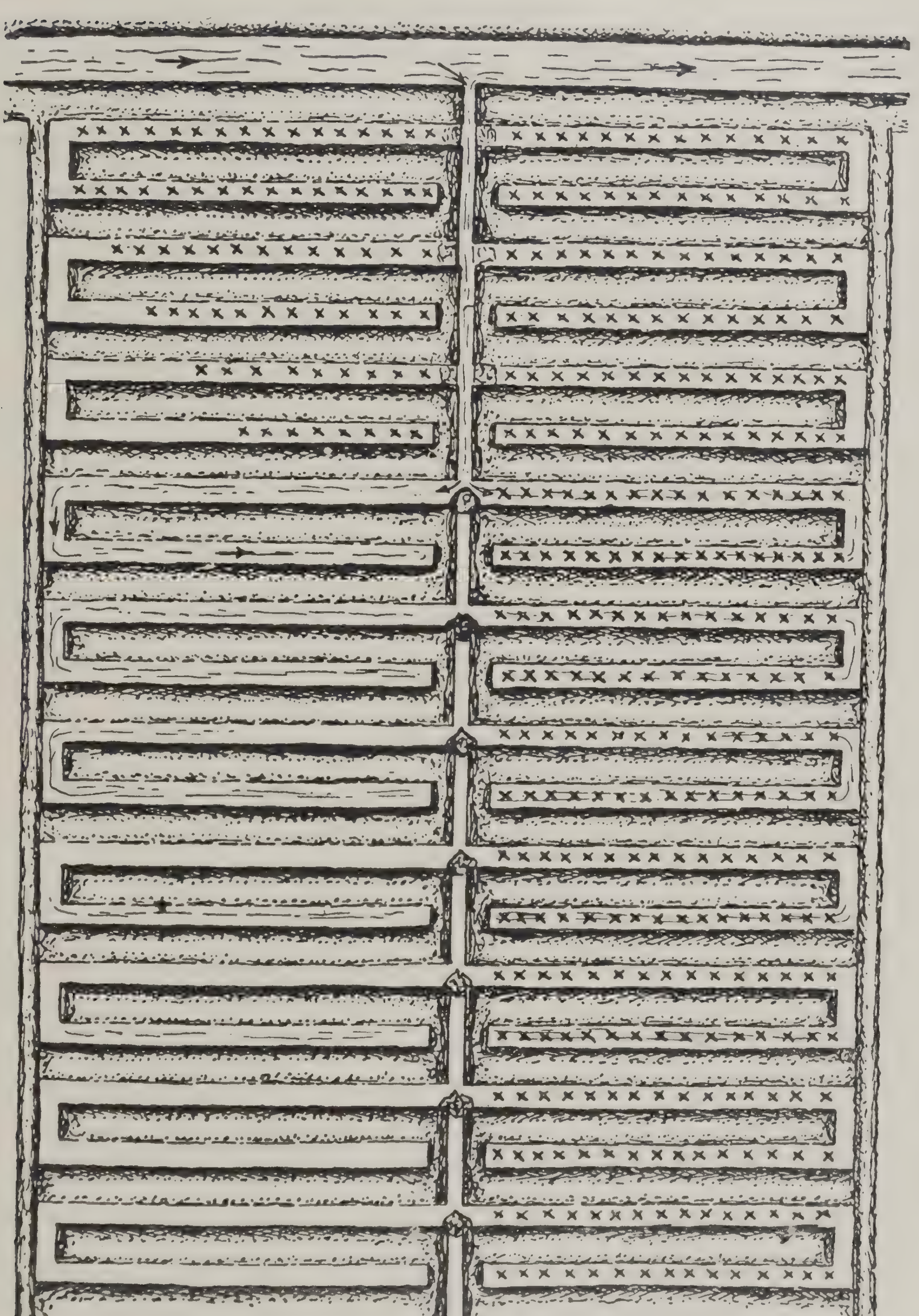

FIG. 3. Ewa or Renton system.

This system which is a combination of cutting one line and the two-way system is practised on the 7,500 acres of Ewa plantation with great success, also in the Waimea region of Kauai. The watercourses are about 70 ft. apart, which is one-half the number in the standard Hawaiian furrow system. Lines are cut so that the water runs to form a U. The irrigator standing on the watercourse can thus see when to change his pani. Water is diverted both to left and right hand sides of the watercourse at the same time.

Grove farm standard system. Here there are three changes in the method during the growth of the crop; the watercourses are 50 ft. apart and the level ditches 300 to 400. Single furrow irrigation is practised for the first three to four months. Then three successive ridges are cut, so that each opening of the watercourse irrigates four furrows; the furrows are thus divided into blocks of four. When the canes are six to eight months old, that is in the spring, the blocks are enlarged, so that 20 to 30 furrows are served by one outlet from the watercourse, and one man can irrigate 5·6 acres in a day. The chief advantage is that the whole plantation can be irrigated in a few days, and this is especially useful where freshets with limited storage occur.

Flooding is not considered practicable as a rule because of the waste of water. It is only possible when the shortage of labour is acute, as was the case in the 1920 Oahu strike. These are the chief variations given of the standard practice of irrigation in the islands. But, with the field thus prepared, the increasing paucity of labour in 1921 induced various planters to think out new methods whose main aim was to save labour, sometimes at a certain cost of efficiency. Labour has become a limiting factor, and a number of novel and ingenious methods have been evolved which are classed together by the author under the heading New Methods. Of these the main idea is to make irrigation as far as possible automatic, and in a recent number of this Journal[1] three methods classed under Kilauea Automatic Irrigation by the author have been described, namely, the Modified Orchard system, the Hillside or Huli-Huli system and Old Ratoons laid down to the standard system but converted to the automatic. The Baldwin Flume system, also automatic, was described at the same time. These systems are one and all of great ingenuity and significance, and the reader is referred to our reference to them for the details. There remain two other systems to complete the number described by the author.

No watercourse system, or simply furrows 200 ft. long between two adjacent level ditches. Renton devised the system and gave it

[1] *Int. Sug. Jour., ibid.*

over to the author to carry out. About 10 furrows can be irrigated at the same time, and the method is at present purely experimental; if the flow is found to be too rapid, it may be readily checked by the insertion of low dams along the furrows at the necessary intervals. The method has received careful study and a table records soil moisture determinations at different distances along the furrows.

Waipio system. This is automatic and is being conducted under the auspices of the Hawaiian Sugar Planters' Association on their sub-station at Waipio. The level ditches are 20 furrows from one another and the furrows are 30 ft. long and must be level. To consolidate the soil and thus prevent washing, the first two or three irrigations are according to the standard method. Then the ridges are cut to 15 ft. lengths, these cuts alternating in successive ridges down the slope. The bottoms of all the cuts must be at the same level, and 3 in. above the bottom of the furrow; the cuts are protected by a mulch of trash or better of paper laid over their lowest part to prevent washing. The whole system is made automatic by outlet boxes in the level ditch, and a gate is placed in the latter between each set of furrows served.

This part of the paper concludes with an experiment conducted by the author at Ewa, in which three systems were compared during nine months in 1921, in a uniform, level field of H 109 plant canes of very vigorous growth. It was one year old at the start when it had approximately 50 tons of cane to the acre; at the time of the last irrigation the weight of cane was estimated as at least 95 tons to the acre. The methods compared were the Ewa system already described, semi-flooding, which was merely an adaptation of the latter whereby, instead of four furrows, 20 to 24 were irrigated at one time, and ordinary cutting of the lines and the resulting zigzag flow of water through the furrows. The latter gave a very slow movement of water, because of the small slope and heavy growth of canes, but no difficulty was experienced with it. The labour saved by the Ewa system was very satisfactory when compared with that of the standard practice, and labour was also saved by the zigzag method. Stripping of the canes, however, could only be done

by the irrigator in the Ewa system and the cost of this operation, which had to be done by an extra man owing to the lack of time, has to be added to the irrigation cost in the other two.

Duty of water. This is the water required to bring the crop to maturity and to obtain the optimum growth. A considerable number of papers have been issued on this subject, but unfortunately there is no uniformity in the standards used, and the canes were grown under very different conditions. The author thinks that, considering the importance of the subject, the information obtainable in Hawaii is very meagre. A summary history of the experiments is given, the results having been converted into comparable figures, and 16 of them have been tabulated. Where possible some of these have been averaged, but in the bulk of them this was not feasible. The following averages are extracted from the table :—

1. Acre-ft. required to bring the crop to maturity, 19·13.
2. Gallons of water per acre to bring the crop to maturity (not so convenient for irrigators but universally adopted in the islands), 6,205,888.
3. Yield of sugar per acre, 6·66 tons.
4. Tons of water to one ton of sugar (although frequently used this is not a recognized standard), 3,898.
5. Tons of sugar from a million gallons of water (safe and more scientific), 1·091.
6. Gallons of water applied per acre per day (deduced from column 2, with 460 days' irrigation for crop), 13,941.
7. Acres covered by one million gallons of water in 24 hours (said to be 100 but the average in the table is), 75·15.

"Verrett's tabulation of the amount of water used at Waipio for the crop of 1921 is 5·9 acre-in. (presumably per irrigation), producing 9·85 tons of sugar, or 2,140 tons of water per ton of sugar. The average interval between irrigations was 20 days, being longer in winter and shorter in summer."

Allen at Waipio experimented for $4\frac{1}{2}$ years on the duty of water on short ratoon crops (12 months ?) and obtained the following results :—

1. Average yield per acre of tons of cane, 36·91, of tons of sugar, 4·46.
2. Water used per acre, in gallons, 2,479,858, in acre-ft., 7·613.
3. Water used per ton of cane, 69,020 gallons or 0·211 acre-ft.
4. Water used per ton of sugar, 582,870 gallons, or 1·789 acre-ft.
5. Lb. of water used for 1 lb. of sugar, 2,421.

(*To be continued.*)

Notes

A POTENTIALLY USEFUL DIAGNOSTIC CHARACTER IN RAPE.

A few plants of rape of a very distinctive yellow green colour somewhat like that of *taramira* without any " bloom " were found in a field at Ranchi some years ago. The variety has been grown at Sabour and has shown very much less contamination by crossing than was expected.

Crosses with the ordinary types are very easily picked out by their more bluish colour and " bloom."

The seed is yellow and somewhat smaller than that of the corresponding normal type. The type seems to be no less vigorous than the common types.

This note is published because such a distinctive character may be of use to those who are working on cruciferous oil-seeds, if only as a means of readily estimating the amount of crossing that takes place under different field conditions. Small samples of seed will be supplied to officers of the Indian Agricultural Service on application to the Economic Botanist, Sabour, Bhagalpur. [A. C. Dobbs.]

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AMERICAN COTTON SITUATION.

The September 1923 issue of the " International Cotton Bulletin " (the official organ of the International Federation of Master Cotton Spinners' and Manufacturers' Association, Manchester) contains a series of interesting articles on the American cotton situation by Messrs. A. S. Pearse and Arthur Foster who have just returned from a tour of the American cotton belt. The first of these " The future of U. S. A. cotton production " gives some startling figures of the present cost of producing cotton in various States. For

instance, in Mississippi 30 cents. per lb. for short staple (i.e., $\frac{7}{8}''$—1″) and 35 cents. for $1\frac{1}{8}''$ cotton, in North Carolina 25 cents., in Central Texas 20 cents. are given as the minimum profitable prices *to the farmer.* In 1918, the U. S. A. Department of Agriculture estimated the cost of production to be 22 cents. in Georgia, 32 in Alabama, 25½ in South Carolina and 21½ in Texas. Owing to the ravages of the boll-weevil and army worm, it is stated that in some parts of Georgia cotton would no longer pay even at 60 cents. or in Mississippi at 40 cents. Even allowing for exaggeration, the authors consider that, under boll-weevil conditions and with a shortage of labour, cotton production in some States has ceased to be economic, that only in Texas and Oklahoma there is a probability of maintaining and increasing production. They consider that there is every possibility that American cotton production will fall to little more than half of pre-war figures and that this would barely supply American mills.

Certainly a 11-million-bale crop from the record area of 38 million acres this year, or say 145 lb. per acre, gives no cause for optimism when compared with 13 million from a similar area in 1920-21, 16 million from the same area in 1914-15 and 15 million in 1911-12 from 36 million acres.

It is estimated that of 38 million acres planted only 1½ million acres were treated with calcium arsenate.

A second article describes the cotton-growers' co-operative movement in the United States of America to which a reference was made in the March (1923) Number of this Journal.

Another article describes in somewhat more detail than any previous publication the organization and methods of the Cotton Crop Reporting Board. The "Bureau reports" have come in for considerable criticism of recent years though at one time held up as a model to the rest of the world. The article describes the reports as very thoroughly prepared "as the result of an analysis of the opinions of the state of the crop on a given date of many thousand peoples." The weak point still is, as always, that the cotton area is only *actually* determined decennially and that for forecast purposes both the area and the yield have to be estimated. That this

is possible at all is due to fortnightly returns of cotton actually ginned and pressed being available. [B. C. BURT.]

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MOSAIC DISEASE.

WHAT scientists declare to be the greatest discovery of the century in the field of plant diseases was announced at the annual meeting of the American Association for the Advancement of Science, which was held at Cambridge, Mass., early in the year.

The declaration was made after reports prepared by Prof. Ray Nelson of the Michigan Agricultural College, Dr. L. O. Kunkel of the Hawaiian Experiment Station, and H. H. McKinney of the University of Wisconsin had been read before the association. In their reports these scientists announced that, during the past year, they had discovered the organisms which cause the "mosaic disease" in various plants and they substantiated their finding by displaying photographs of these organisms actually at work.

IMPORTANT TO SUGAR INDUSTRY.

While this discovery is of great import to all plant pathologists, it is of special interest to those who are concerned with the study of the diseases of the sugar-beet and sugarcane, for the reason that the mosaic disease is increasing every year and it is estimated that it results in the loss of tens of thousands of dollars' worth of sugar plants annually.

For many years plant pathologists have been searching for the cause of the mosaic disease, on the theory that if they could find the organisms they could devise means of controlling the disease. With the finding and photographing of these organisms accomplished, the mystery of the disease has been revealed.

The organism is described as having a long spindle-shaped body with whip-like hairs (cilia) at each end. They are considered as belonging to the most primitive forms of animal life, the protozoa. They are less than one hundred-thousandth of an inch thick and from ten to twenty times as long. They attack the cell in its most

vital spot, the nucleus. Some of them have been found actually coiled about the cell nucleus.

Specimens found in potatoes.

While it is true that scientists have believed for some time that the mosaic organisms belonged to the animal kingdom, no one was able, until recently, to prove this a fact, nor had anyone been successful in observing the organisms actually engaged in their depredations. Prof. Nelson reported that he had found the organisms by cutting thin sections of the inner part of infected potato stems and examining them under a high-powered microscope.

It has also been found that there are various kinds of these organisms, each preying on particular sort of plant. The organisms discovered by Prof. Nelson are those that infest beans, sugar-beets, clover, tomatoes and potatoes. These creatures are similar to the trypanosome, the cause of the sleeping sickness which kills man and beast in Africa.

Dr. Kunkel and H. H. McKinney announced the discovery of the parasites that cause the mosaic disease in corn and wheat plants. It was found that these organisms belong to the class known as amœba and are similar to the organisms causing malaria and yellow fever in man, which are transmitted from man to man by the mosquito.

While it is too early to announce the measures to be taken in the control of these organisms, it is the belief of many prominent botanical pathologists that their discovery may be the beginning of a new era in the treatment and cure of many plant diseases.

* " A factor to which too little attention has heretofore been paid in surveying crop conditions and prospects in Cuba is the mosaic disease of sugarcane, which by reason of its widespread existence and increasing dispersion seems to have reached a point where it deserves consideration along with the rainfall and weather conditions in general. Just how much territory in Cuba has been invaded by this disease, and to what extent, has never been

* This and subsequent paragraphs are taken from *Facts about Sugar*, XVII, 2.

determined by an accurate survey, although it has been known to exist in several parts of the island for a number of years. The reasons for this lack of attention to what, in other countries, has been recognized as one of the most serious menaces to successful cane agriculture have been various, but the principal ones have been the abundant crops of the past few years, the reluctance on the part of the managements of certain estates to admit the occurrence of the disease on their properties or to recognize its importance, and the desire of the Department of Agriculture to wash its hands of a problem too big for it to attack successfully.

" In Porto Rico the disease has been regarded as the worst scourge known in the cane fields and energetic measures, which give every promise of being successful, have been undertaken for its control. In Hawaii it has been held in check by the planting system employed and the practice of a rigid selection of seed cane. In Java its importance has long been acknowledged and control measures employed.

Cuban conditions favour spread.

" Cuban conditions and field practice are particularly favourable to the spread of the disease, as replanting is infrequent on good soils and, especially in recent years, the principle of selection of seed cane has been the reverse of that employed in the other countries mentioned, the best cane being sent to the mill and that of poorer quality saved for planting. This practice, combined with lack of information on the part of the field management of estates, has been the cause of extensive planting of seed cane affected by the disease, every stalk of which produces a diseased stool. As the ill effects are not at once visible to the eye, entire diseased fields have passed unnoticed, and only a comparative analysis would show the extent of the resulting losses.

" Recently there have been signs of a partial awakening among estate managements to the serious nature of the situation produced by former neglect, and a growth of interest in the means of combating the disease. Although individual estates, by proper measures, can rid their own fields of the disease, its complete eradication is

something that can only be accomplished by co-operation among the mills to this end and by unflagging effort. Further attention to this serious factor in the industry will be given as new information on the subject is forthcoming." [*Cuba Review*, XXI, 10.]

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LODGING OF SUGARCANE: MEANS OF PREVENTION.

It is not generally appreciated that the lodging of sugarcane in the fields has other consequences than the extra difficulties in cutting, handling and milling badly fallen cane. When a stalk of cane falls or is blown down, its growth is checked and the quality and yield of juice suffer appreciably. The difference between fallen and standing cane at the time of cutting will show up clearly if the two are harvested and worked up separately, as is illustrated by the following figures given by Geerts in *Java Archief* No. 22, 1923. The cane in question was D 152 grown in Godeo.

	Brix	Sugar %	Purity %	White sugar %
		Standing cane.		
Base	19·11	17·81	93·25	17·29
Middle ..	19·91	18·55	93·22	18·01
Top	17·90	15·40	85·98	14·39
		Fallen cane.		
Base	16·32	14·02	85·95	13·09
Middle ..	17·50	15·89	90·74	15·23
Top	15·38	12·26	79·61	11·00

Losses due to lodging.

The average purity of the standing cane was 91·15 per cent. and the sugar content 17·31 per cent., that of the fallen was 85·87

and 14·10 per cent., respectively. This sufficiently indicates that lodging on any extensive scale has more serious consequences than annoyance in handling and milling. Moreover, the average weight of the fallen canes is smaller.

The causes of lodging are many and various, but for the most part are referable to definite factors. When whole fields are blown down by heavy winds there is, of course, no doubt as to the cause, but when, in the absence of such accidents, the percentage of fallen cane varies from one field to another or in different parts of the same field the predisposing causes are less obvious and it has required much observation and experiment to deduce the underlying factors.

One cause is a predisposition of the cane itself, i.e., some varieties of cane are more predisposed to lodge than others. The variety 100 POJ, for example, is one which lodges badly, whereas EK 2 and D 152 show much less tendency in this direction.

Another cause is connected with climatic and moisture conditions. If during the earlier period of its growth the cane is not well supplied with moisture, it is liable to develop a spindling stalk, and if at a later period the moisture conditions improve, the cane develops a heavy top growth and the tendency to lodge is greatly increased.

A third cause is irrational fertilizing of cane fields. Lodging is always more frequent in heavily fertilized plots. The application of fertilizer, of course, increases the yield, but if the tendency to lodge is trebled or quadrupled, as, from experiments quoted by Geerts, often occurs, the resulting depreciation of the lodged cane may considerably discount the benefit of the added fertilizer. On naturally rich ground application of fertilizer may even result in a smaller total yield of cane as well as a poorer yield of juice.

Measures to prevent lodging.

The measures to be taken against lodging are, first, the selection of a variety little disposed to this trouble especially for rich, wet soils.

The method of planting is not without influence. Shallow planting, as practised under the plough system in Java, results in much stooling and more fallen cane than is observed in the "raynoso" system. Suckering the cane and planting wider apart results in stockier growth and smaller tendency to lodge.

The control of lodging by judicious fertilizing is more uncertain and requires long observation and some experimenting on different soils to learn their peculiarities. Strong land should not be given as heavy applications as poor soil.

Some writers have advocated tying together stalks in opposite rows. This is more or less effective, but costly and productive of bent cane which is not easy to transport or feed to the mill. A more serious objection is that the tops of the cane are crowded together, which has an unfavourable effect on the rendement. Other measures that have been proposed are stripping some of the lower leaves of the young cane or the cutting off the top of the cane about $2\frac{1}{2}$ inches above the upper node. Such measures check the growth of the cane and where they diminish lodging they also diminish yields and profits. [*Facts about Sugar*, XVII, 15.]

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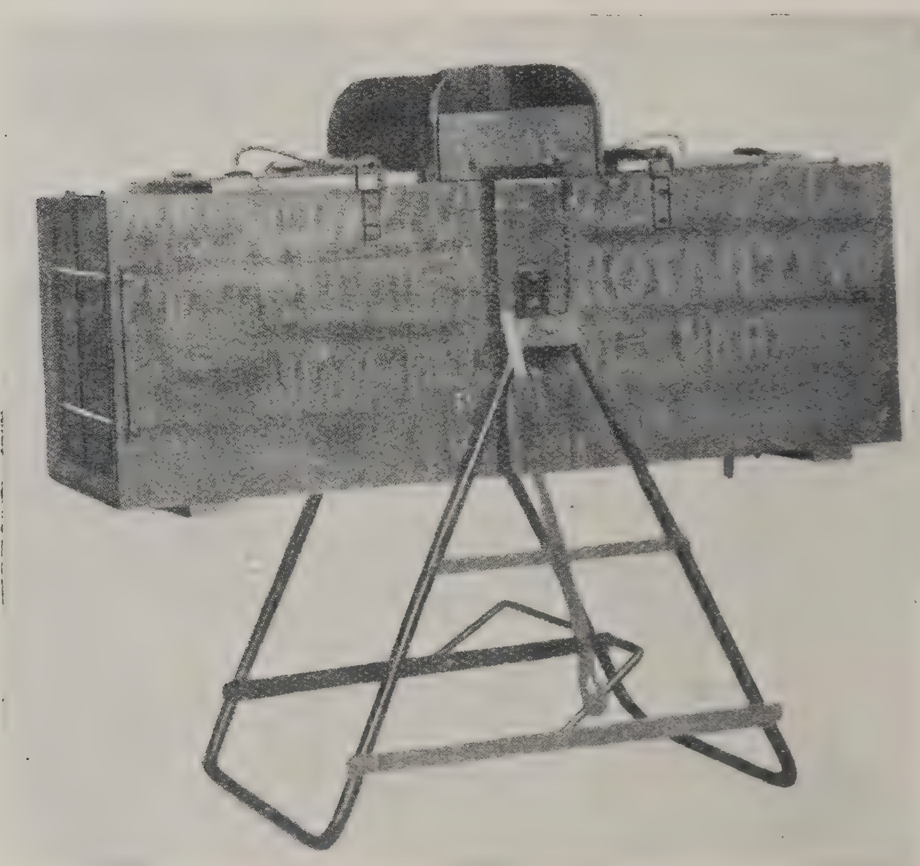
AN EFFECTIVE WHEAT PICKLING MACHINE.

We often hear of bunt in wheat crops, the seed of which is supposed to have been effectively pickled. Nevertheless, if the pickle has been used at the right strength, and if each wheat grain has been thoroughly "wetted" by it, apart from occasional soil re-infection, there should be little or no bunt in the crop.

Frequently in my opinion, lack of success in pickling is to be attributed to the way with which the pickle is applied rather than to the nature or strength of the pickle itself. Thus, merely dipping a wheat-butt into a cask containing pickle, and leaving it there for a few minutes, does not in any way insure that each grain is thoroughly "wetted" by the pickle. As a matter of fact the surface of the grain is more or less greasy in character, and water seems to slip over it readily or to adhere to it loosely in the form of numerous minute air bubbles beneath which the surface remains

dry. Hence, many a spore of bunt escapes contact with the pickle and lives to germinate later on in the field in contact with the grain.

It is these facts which, in my opinion, render floor pickling more effective than the various mechanical methods hitherto recommended. Unfortunately, it is a long and laborious process



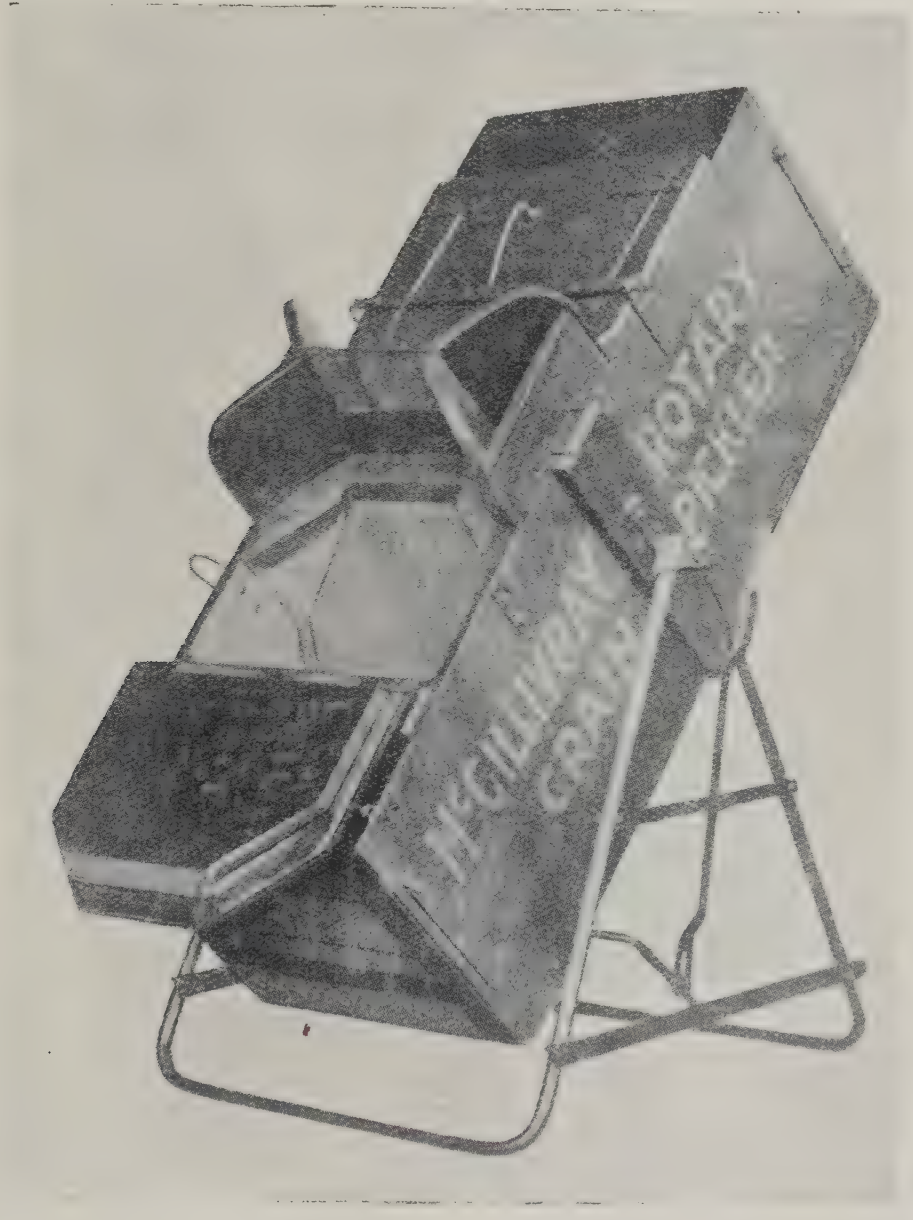
No. 1.

which we would willingly avoid if we could. Personally, for many years I have held the opinion that if floor pickling was ever to be effectively superseded it would be by some form or other of a rotary pickling machine. On the suggestion of Mr. H. J. Apps, we endeavoured to use for the purpose an old rectangular butterchurn, which, although quite effective from the point of view of the distribution of the pickle, was too slow for general purposes.

Quite recently, however, I have come across a new type of rotary pickler, the invention of a South-Eastern farmer—Mr. J.

McGillivray—which appears to me to have solved pickling difficulties very effectively.

It consists of a long, rectangular, watertight, wooden box, divided into three compartments by two sloping brass screens,



No. 2.

one of which is shown in illustration herewith. The box is mounted on a triangular iron frame around which it rotates freely. An ingenious lever-stop arrangement enables one to place the box in the various positions indicated in the illustrations.

The pickler is adapted to pickle one bag at a time, one half being placed in one compartment and the other in the opposite one.

When filling the pickler the box is brought to position 2; the doorway is thrown back and from $2\frac{1}{2}$ to 3 gallons of 1 per cent.

No. 3.

bluestone pickle should be poured into it. I indicate this quantity because in our experience it takes $2\frac{1}{2}$ gallons of solution to floor pickle effectively one bag of wheat; a slight excess of solution will do no harm. Half a bag of wheat should then be emptied into the open compartment, and the door closed down. The box should then be reversed and a second half bag emptied into the opposite compartment. The box should then be made to rotate slowly around its axis; a slight push will bring this about. As the box rotates the grain will be thrown violently against its sides and be

brought effectively in contact with the pickle. Four or five minutes' rotation should suffice for the purpose.

The box is then brought to position 3, the trap door opened and the grain made to slide into a bag attached beneath the central lip. It is then reversed and the grain from the opposite compartment emptied out in the same way.

The whole mechanism is exceedingly simple and should, in my opinion, prove very effective for pickling wheat either with solutions of bluestone or formalin, or even with a dry powder like copper carbonate. [ARTHUR J. PERKINS in *Jour. Dept. Agri. South Australia*, XXVII, No. 1.]

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NEW OFFICIAL UNIVERSAL STANDARDS FOR AMERICAN COTTON.

A RECENT Bulletin issued by the United States of America Department of Agriculture describes the new American official cotton standards, and the following abstract explains the variations from the previous American standards :—

1. *Establishment and replacement of the official cotton standards of the United States.*

Section 9 of the United States Cotton Futures Act, approved August 18, 1914, and re-enacted August 11, 1916, confers upon the Secretary of Agriculture the authority to establish standards of cotton by which its quality or value may be judged or determined, including its grade, length of staple, strength of staple, colour, and other qualities, properties, and conditions, and to change or replace the same from time to time. Notice must now be given at least one year in advance of the effective date of any change or replacement of the standards that have been established under the Act.

2. *Grades and colours of American upland cotton.*

Standards for nine white grades of American Upland cotton were established and promulgated by public notice of the Secretary of Agriculture on December 15, 1914, as follows : Middling Fair,

Strict Good Middling, Good Middling, Strict Middling, Middling, Strict Low Middling, Low Middling, Strict Good Ordinary, and Good Ordinary.

By order of the Secretary of Agriculture, dated January 28, 1916, standards for colour in the various grades of American Upland cotton were established as follows: Good Middling Yellow Tinged, Strict Middling Yellow Tinged, Middling Yellow Tinged, Strict Low Middling Yellow Tinged, Low Middling Yellow Tinged, Good Middling Yellow Stained, Good Middling Blue Stained, Strict Middling Blue Stained, and Middling Blue Stained.

On August 12, 1916, by reason of the re-enactment of the United States Cotton Futures Act on the preceding day, the same standards for grades and colours of American Upland cotton were re-established without change.

No change has been made in these standards for American Upland cotton from the date of their original establishment until July 26, 1922, when an order was issued by the Secretary of Agriculture, effective August 1, 1923, making certain changes in the existing standards including the method of designating the grades and colours. These changes are designed solely to provide a more satisfactory classification of cotton already within the range of the present standards.

In the white grades the changes are not considerable and the new standards represent the nine grades for which the standards were originally established. The most noticeable changes are in Middling Fair and Strict Good Middling, which in the new boxes are somewhat less creamy and admit a trifle more leaf. The reason for this change is that in the old standards for these grades too large a proportion of creamy cotton was allowed in relation to the lower boxes. Great care has been taken to graduate all of the new boxes so that the steps between the grades shall be as nearly equal as practicable.

The extension of the boll-weevil depredations into practically all sections of the Cotton Belt has caused the greater part of the American crop to show some slight discoloration, known as boll-weevil spots. The new white standards provide for such colour

in the white grades, but do not contain as much heavy spot as bales 3 and 11 of Strict Low Middling, 7 of Low Middling, 5, 6, 8 and 9 of Strict Good Ordinary, or 3 and 7 of Good Ordinary of the old standards.

(NOTE. For an explanation of the system of arranging and designating the type samples in the boxes of the Official Cotton Standards of the United States see Service and Regulatory Announcements No. 6 of the Office of Markets and Rural Organization.)

The old standards for yellow tinged cotton have never received the complete recognition of the cotton trade. The new standards, being much lighter in colour, are designed to conform more closely to American trade ideas.

One important objection to the old standards as a whole, brought forward by the trade, was the lack of specific designation for cotton intermediate in colour between the practical forms. This complaint was recognized as having considerable merit, especially in view of the wide differences in the values of the grades which have prevailed in recent years. The new standards, therefore, provide for a more exact classification of cotton the colour of which is lighter or deeper, as the case may be, than that shown in the practical forms without multiplication of the practical forms and the attendant increase of expense.

The numerical method of grade designation for cotton which was introduced in the American, Egyptian and Sea Island standards has been extended to the standards for American Upland cotton, in keeping with the general policy of the Bureau of Agricultural Economics (formerly the Bureau of Markets) to employ numbers for the grades of all commodities for which it has established standards, assigning No. 1 to the highest commercial grade and succeeding numbers to lower grades in order. Inasmuch as the standards for the white grades govern in all determinations of preparation, leaf trash, and other foreign material, while the standards for colour determine only the ranges of colour under the respective designations without reference to other considerations, the colour standards are denoted by descriptive words affixed to the grade numbers. Examples of the use of each designation

are found in the table given below. The use of the full grade nomenclature, however, is continued in addition to the numerical designations.

Blue Stained	*Gray*	**Standards for grades of Upland cotton white**	*Spotted*	**Yellow Tinged**	*Light Stained*	**Yellow Stained**
		1 or M.F.				
		2 or S.G.M.		*2 T.*		
3 B.	*3 G.*	**3 or G.M.**	*3 Sp.*	**3 T.**	*3 L.S.*	**3 S.**
4 B.	*4 G.*	**4 or S.M.**	*4 Sp.*	**4 T.**	*4 L.S.*	**4 S.**
5 B.	*5 G.*	**5 or M.**	*5 Sp.*	**5 T.**	*5 L.S.*	**5 S.**
		6 or S.L.M.	*6 Sp.*	**6 T.**		
		7 or L.M.	*7 Sp.*	**7 T.**		
		8 or S.G.O.				
		9 or G.O.				

Symbols in **heavy type** denote grades and colours for which practical forms of the Official Cotton Standards are prepared. Symbols in ***italics*** represent the designations of cotton which in colour is between practical forms of the same grades.

The grades shown above the horizontal line are deliverable on future contracts made in accordance with Section 5 of the United States Cotton Futures Act. Those below the line are untenderable on such future contracts.

[*Service and Regulatory Announcements of the Bureau of Agricultural Economics*, No. 72, 1922.]

The following abstract from the *Textile Mercury* shows the correspondence of the new American standards with the Liverpool standards :—

" The Manchester Cotton Association has received the following cable from the delegates at Washington stating that the European delegates have carefully compared the new American standards with the Liverpool standards in Washington and consider standard grades as follows :—

American Strict Good Middling=Liverpool Middling Fair.

American Good Middling=Liverpool Fully Good Middling.

American Strict Middling=Liverpool Good Middling.

American Middling=Liverpool Fully Middling.

American Strict Low Middling=Liverpool Fully Low Middling to Middling.

American Low Middling=Liverpool Low Middling to Fully Low Middling.

American Strict Good Ordinary=Liverpool Fully Good Ordinary to Low Middling.

American Good Ordinary=Liverpool Good Ordinary to Fully Good Ordinary.

"The delegates consider the standards satisfactory and even running. The standards have been made up from compressed cotton, but owing to the cotton not touching the box lid the standards have an uncompressed appearance."

There has been considerable controversy about the changes in standards, and the American standpoint is well explained in the article by Mr. Brand, reproduced in the January Number of this Journal (XIX, 1, 1924).

As a result of the deputation sent by the Liverpool Cotton Association to America, an agreement now appears to have been reached on most of the points at issue. It is understood that the American Government has agreed to supply the American standards to the Liverpool and Manchester Cotton Exchanges, and a compromise has been reached in regard to the difficult question of arbitrations. Under the Act passed recently the Washington arbitration will be final. This was strongly objected to by the Liverpool Cotton Association as it meant the overriding of their arbitrations. On the other hand, American opinion considered it essential that sellers should be able to obtain an official classification of their cotton in America and no longer be dependent on arbitrations carried out abroad against standards with which they are not familiar. From the cable reports it now appears clear that the Liverpool Cotton Association's arbitrations based on the new American standards will be recognized as authoritative. [B. C. BURT.]

COTTON RESEARCH.

THROUGH the courtesy of the British Cotton Industry Research Association, the Secretary of the Indian Central Cotton Committee has sent the following abstracts for publication :—

BOLL-WEEVIL TRAP.

An apparatus for protecting seeds and crops from insects and particularly for destroying boll-weevils on cotton consists of a cage-like device carrying a number of radial rods provided with down-turned bristles, wires or strings. This cage travels over the crop on an over-head wire. It is provided with conical passages to afford ready access for insects to the interior where strips of material soaked in sticky poisonous substance having an odour attractive to insects are suspended. The insects fall into a tank in the form of a drawer which can be filled with water or paraffin as desired. A lamp may be fitted within the cage. The rods on the outside of the cage may be coated with adhesive. The hanging strings engage the top of the crop and disturb the insects thereon. [*E. P.* 199867. J. SMITH-ROSS.]

COTTON DISEASES IN WEST AFRICA.

Short descriptions, with illustrations, are given of the cotton diseases met with in West and South-West Africa. The diseases and the causative organisms include— angular leaf spot (*B. malvacearum*), wilt (*Neocosmospora vasinfecta*), anthracnose (*Glomerella gossypii*), sore shin (*Pythium debaryanum ?*), a "rust" (*Uredo gossypii*), and two less serious pests characterized by spotting and shedding of the leaves (*Ramularia areola* and *Mycosphærella gossypina*). [*Text. Mercury*, 1923, **69**, 206-207. R. SWAINSON-HALL.]

FUMIGATION OF COTTON-SEED.

Cotton-seed badly infested with pink boll-worm is completely disinfected by exposing it to chloropicrin, to the extent of 30 c.c. per cubic metre, for 24 hours. The germinating power of the seed is unaffected. [*Expt. Sta. Rec.*, 1923, **49**, 154 ; from *Agron. Colon.*, 1922, **7**, 249–253. P. VAYSSIERE.]

Dimensions of starch grains.

Using a high-power microscope equipped with a micrometer eye-piece, the authors have determined the sizes of the starch grains in seven typical flour samples. It was found that the starch grains could be grouped in two classes, those having diameters of 7 microns or less and those having diameters of 8 microns or more. The percentage of starch grains of different sizes in each sample of flour was ascertained. The results indicate a relationship between sizes of grains and strength of flours. The greater the percentage of small grains the stronger the flour. [*Ind. Eng. Chem.*, 1923, **15,** 1050-1051. J. H. Buchanan and G. G. Naudain.]

Gossypol toxicity.

Pepsin and trypsin digest casein and the globulin of the cotton-seed to very nearly the same extent and at practically the same rate through an extended period. The addition to the protein of 1 per cent. of its weight of the toxic principle, gossypol, present in cotton-seed kernels to the extent of 1·5 to somewhat more than 5 per cent. of the estimated protein content, interferes markedly with the digestion in vitro of the cotton-seed globulin by pepsin and trypsin, and by pepsin alone, as well as the digestion of casein by pepsin and trypsin. The incomplete digestion (83 per cent.) by animals of the protein content of cotton-seed press-cake preparations is tentatively explained as an inhibitive effect of gossypol. [*Jour. Biol. Chem.*, 1923, **56,** 501–511. D. B. Jones and H. C. Waterman.]

Advantages of heavy seeds.

Water culture experiments with peas and barley are described which were designed to show the effect of weight of seed on the resulting crop. The results indicate that there is a steady rise in the dry weight of the plants as the initial weight of the seed increases, whether the food supply is limited or abundant. The "efficiency index" (rate of increase per day), however, falls gradually as the weight of the seed rises, so that the initial advantage accruing from heavy seed might be lost with prolonged periods of growth.

With annual crops, harvesting occurs before this point of equilibrium is reached. [*Ann. Appl. Biol.*, 1923, **10**, 223–240. WINIFRED E. BRENCHLEY.]

CAUSES OF MILDEW.

A general article and discussion describing some of the causes of mildew in cotton cloth. [*Jour. Man. Col. of Tech. Text. Soc.*, 1923, **13**, 20–25. P. BEAN.]

ADSORPTION.

After a short general review of the main theoretical and practical details of adsorption or sorption the author describes the two chief theories which are at present under discussion, one of which is based on a consideration of the compressed or condensed condition in which a gas will exist if brought within the zone of attraction of a solid, and the other on the conception of the unimolecular layer. Brief reference is made to some of the practical applications of a knowledge of sorption. [*Jour. Soc. Dyers*, 1923, **39**, 233–238. J. W. MCBAIN.]

DESCRIPTION OF COTTON GIN.

In a process for the removal of the residual hairs retained by cotton-seed after ginning, or for the removal of hairs from the decorticated hulls of cotton-seed or other fibre-bearing material, the heavily-loaded seeds are segregated from the hairless or lightly covered seeds at any stage of the process, and subjected to a further defibrating operation. The segregator, which is separate and distinct from the defibrating machine, comprises a shallow dish formed with a central compartment with a sloping floor roughened or coated with abrading material. The dish is suspended from a support and subjected to a wobbling or shaking movement. The seeds are fed to the outer compartment, and those with little or no fibre gravitate to the bottom of the mass and fall through an opening, with a closing shutter, in the floor of the outer compartment above a shoot leading to a conveyer ; the more heavily-loaded seeds tend to collect at the upper level of the mass and pass through openings

in the wall and floor of the central compartment to be returned to the defibrating machine. [*E. P.* 198561. E. C. de Segundo.]

Viability of cotton-seed.

The fungus which is responsible for cotton anthracnose, and which infects the cotton-seed, is completely destroyed by heating the thoroughly dried seed in a vacuum or any inert atmosphere, such as nitrogen, to prevent oxidation of the fats and proteins, after which the seed will endure the temperature of boiling water for hours without affecting its vitality. Seed so treated has a much higher percentage germination than untreated seed. [*Science*, 1923, **57**, 741-742. G. F. Lipscomb and G. L. Corley.]

PERSONAL NOTES, APPOINTMENTS AND TRANSFERS, MEETINGS AND CONFERENCES, ETC.

Mr. S. Milligan, M.A., B.Sc., Agricultural Adviser to the Government of India, and Director, Agricultural Research Institute, Pusa, has been granted leave for six months on average pay from 1st March, 1924, Dr. D. Clouston, C.I.E., officiating.

***

The services of Mr. G. S. Henderson, N.D.A., N.D.D., Imperial Agriculturist, Pusa, have been placed at the disposal of the Government of Bihar and Orissa to officiate as Director of Agriculture, during the absence on leave of Mr. A. C. Dobbs.

***

Dr. F. J. F. Shaw, D.Sc., Second Imperial Mycologist, Pusa, has been granted leave on average pay for six months from 15th March, 1924.

***

Mr. Rudolph D. Anstead, M.A., has been confirmed as Director of Agriculture, Madras, from 22nd December, 1923.

***

Mr. A. C. Edmonds, B.A., Deputy Director of Agriculture, I Circle, Madras, has been granted combined leave for nine months from 4th March, 1924, Mr. K. T. Alwa being placed in charge.

***

Mr. F. T. T. Newland, Government Agricultural Engineer, Madras, has been granted leave on average pay for one month and two days from 16th March, 1924.

***

Dr. R. V. Norris, D.Sc., M.Sc., F.I.C., who retires from the Indian Agricultural Service, has been appointed Professor of Bio-Chemistry in the Indian Institute of Science, Bangalore.

Mr. B. Ramayya, B.Sc., has been appointed to act as Deputy Director of Agriculture, II Circle, Madras.

***

Mr. W. J. Jenkins, Deputy Director of Agriculture, North Central Division, Bombay, has been granted combined leave for nine months from 1st May, 1924.

***

Mr. M. Carbery, M.A., B.Sc., Agricultural Chemist to the Government of Bengal, has been granted leave on average pay for six months from 11th March, 1924, Mr. G. B. Pal, M.Sc., officiating.

***

Mr. P. J. Kerr, M.R.C.V.S., Director, Civil Veterinary Department and Veterinary Adviser to the Government of Bengal, has been granted leave on average pay for eight months from 26th February, 1924.

***

Mr. R. T. Davis, M.R.C.V.S., Vice-Principal, Bengal Veterinary College, has been appointed to act as Director, Civil Veterinary Department, Bengal, during the absence, on leave, of Mr. P. J. Kerr or until further orders.

***

Maulvi Saiyid Sultan Ahmad, G.B.V.C., Lecturer, Bengal Veterinary College, has been appointed to act as Vice-Principal, Bengal Veterinary College, *vice* Mr. R. T. Davis.

***

On completion of their probationary period, the following officers are confirmed in the Indian Agricultural Service with effect from 1st December, 1923 :—

(1) Dr. P. E. Lander, M.A., D.Sc., Agricultural Chemist to Government, Punjab, Lyallpur.

(2) Mr. H. R. Stewart, A.R.C.Sc.I., D.I.C., N.D.A., Professor of Agriculture, Punjab Agricultural College, Lyallpur.

(3) Mr. D. P. Johnston, A.R.C.Sc.I., N.D.A., Deputy Director of Agriculture, Lyallpur.

***

Mr. A. McKerral, M.A., B.Sc., has been confirmed as Director of Agriculture, Burma, from 26th November, 1923.

***

Mr. J. Charlton, M.Sc., A.I.C., Agricultural Chemist, Burma, has been appointed Principal of the Mandalay Agricultural College, in addition to his own duties, from 1st December, 1923.

***

Mr. F. J. Plymen, A.C.G.I., Agricultural Chemist to Government, has been appointed to officiate as Director of Agriculture, Central Provinces, *vice* Dr. Clouston on other duty.

***

Dr. H. E. Annett, D.Sc., has been appointed to officiate as Agricultural Chemist to Government, Central Provinces, *vice* Mr. Plymen on other duty.

***

Mr. W. Youngman, B.Sc., Economic Botanist to Government, Central Provinces, has been appointed Economic Botanist for Cotton from 1st November, 1923.

***

Mr. Jehangir Fardunji Dastur, M.Sc., D.I.C., Mycologist to Government, Central Provinces, has been appointed to hold charge of the post of Second Economic Botanist, in addition to his own duties, from 1st November, 1923.

***

Mr. H. Horsman, Director, Swadeshi Cotton Mills Company, Limited, Cawnpore, has been nominated by the Upper India Chamber of Commerce, Cawnpore, to be a member of the Indian Central Cotton Committee, *vice* Mr. A. Horsman, resigned.

Mr. F. G. Travers, of Messrs. Gill & Co., Bombay, has been nominated by the Karachi Chamber of Commerce to be a member of the Indian Central Cotton Committee, *vice* Mr. H. C. Short, resigned.

***

The Thirteenth Meeting of the Board of Agriculture in India was held at Bangalore in the Daly Memorial Hall from 21st to 26th January, 1924. This was the first occasion on which the Board met in an Indian State. His Highness the Maharaja of Mysore evinced his deep interest in its deliberations by graciously consenting to preside at its opening meeting. His Highness, who was accompanied by Their Excellencies the Resident and the Dewan and other high officials and notables of the State, in welcoming the Board, delivered a most inspiring speech which was highly appreciated by all who had the pleasure of listening to it. The Board was attended by 41 members and 30 visitors. There were eleven subjects on the agenda, three of which relating to questions of cattle-breeding and animal husbandry were initially threshed out by a Cattle Conference held simultaneously with the Board. A detailed account of the meeting, together with a photograph of the Board, will be issued in the next number of the Journal.

Review

The Empire Cotton Growing Review (London: A. & C. Black, Ltd.; Quarterly—Annual subscription 5 shillings), the official organ of the Empire Cotton Growing Corporation, the first issue of which has been published with New Year, is a valuable addition to the growing literature on cotton. The Journal is intended not only to keep those interested informed of the activities of the Corporation, but also to publish information concerning cotton growing problems throughout the Empire, thus acting as a clearing house of intelligence collected from different Dominions and Colonies, and keeping Directors of Agriculture and others engaged in cotton growing in touch with development and experiments elsewhere. Statistics of the cotton crops of the world, together with their qualities and uses to which they are put, will form a regular feature of the Journal, and it is hoped to make it an instrument of giving both spinners and growers "a better knowledge of one another's lives, experiences, requirements and difficulties."

The first number, although, as explained, largely "historical and tentative," gives good promise of the fulfilment of the aims and objects with which the Journal has been started. After a short history of the formation and working of the British Cotton Growing Corporation, the place of honour has been given to an appreciation, by Dr. Lawrence Balls, of the late J. W. McConnel, the first Chairman of the Council of the Corporation, who, more than any other man, gave the cotton industry a new technical organization comparable with its existing industrial equipment. The Imperial College of Tropical Agriculture forms the subject of the next article from the pen of Sir Francis Watts, while of special interest to India is an excellent description of the working and programme of the Indian Central Cotton Committee by its energetic Secretary. Mr. Cecil Wood, who is doing important work for the Corporation in

Tanganyika, follows with an interesting paper on the prospects of cotton growing in this former German possession. There are two papers of purely scientific interest by L. H. Burd, one of which deals with the botanical work of the late William Robson, while the other records a sterile dwarf rogue in the Sea Island cotton. Cotton growing statistics are in the safe hands of Prof. John Todd. The issue winds up with " notes on current literature," which although not pretending to cover the whole ground of cotton literature, are by no means the least important feature of the Journal.

We commend this periodical to the notice of all interested in the development of cotton. [EDITOR.]

Correspondence

NATURAL CROSS-POLLINATION IN INDIAN LINSEED.

TO THE EDITOR OF THE *Agricultural Journal of India.*

SIR,—Our attention has been drawn to a paper entitled "Linseed (*Linum usitatissimum*) hybrids" in the previous number of the *Agricultural Journal of India* (XIX, 1924, pp. 28–31) by Dr. R. J. D. Graham and Mr. S. C. Roy, in which it is stated that *the occurrence of natural cross-pollination of linseed has not previously been noted in India.* This statement is not correct. In October 1910 we published a paper—The economic significance of natural cross-fertilization in India—in the *Memoirs of the Department of Agriculture in India* (*Botanical Series*), III, 1910, pp. 281–330, in which the occurrence of natural cross-pollination in single plant cultures of linseed in India was for the first time recorded. This is referred to in the *Handbuch der landwirtschaflichen Pflanzenzüchtung*, Vol. III, 1922, p. 49. In December 1919, we published a further paper—Studies in the pollination of Indian crops I—in the *Memoirs of the Department of Agriculture in India* (*Botanical Series*), X, 1919, pp. 195–220, in which the results of our studies on the flowering and pollination (including the occurrence of natural cross-pollination) of Indian linseed are set out in great detail together with the necessary illustrations. Between 1916 and 1918 no less than 21 cases of natural cross-pollination between the unit species of Indian linseed were observed and investigated. These various publications appear to have escaped the notice of Messrs. Graham and Roy.

PUSA :
9th January, 1924.

Yours faithfully,
ALBERT HOWARD.
GABRIELLE L. C. HOWARD.

NEW BOOKS

ON AGRICULTURE AND ALLIED SUBJECTS

1. Farm soil and its improvement, by Sir John Russell. Pp. 126 +37 plates. (London : Ernest Benn, Ltd.) Price, 7*s.* 6*d.* net.
2. The Micro-organisms of the Soil, by Sir John Russell and Members of the Biological Staff of the Rothamsted Experimental Station. Pp. vii+188. (London : Longmans, Green & Co.) Price, 7*s.* 6*d.* net.
3. The Foundations of Indian Agriculture, by H. Martin Leake, M.A., Sc.D. Second Edition. (Cambridge : W. Heffer and Sons.) Price, 7*s.* 6*d.* net.
4. Diseases of Crop Plants in the Lesser Antilles, by W. Nowell, D.I.C. Pp. 382+150 figs. (London : West India Committee.) Price, 12*s.* 6*d.* net.
5. Successful Spraying, and how to achieve it, by P. J. Fryer. Pp. 154. (London : Ernest Benn, Ltd.) Price, 7*s.* 6*d.* net.
6. Agricultural Implements, by G. H. Purvis. Pp. iv+110. (London : Ernest Benn, Ltd.) Price, 2*s.* 6*d.* net.
7. Vegetable Crops, by Homer C. Thompson, B.Sc. Pp. ix+478. (London : McGraw-Hill Publishing Co.) Price, 22*s.* 6*d.* net.
8. The Principles of Insect Control, by Robert A. Wardle and Philip Buckle. Pp. xvi+295. (London : Longmans, Green & Co.) Price, 20*s.* net.

THE following publications have been issued by the Imperial Department of Agriculture in India since our last issue :—

Memoir.

1. Studies in Indian Oil Seeds, No. 2. Linseed, by Gabrielle L. C. Howard, M. A. ; and Abdur Rahman Khan. (Botanical Series, Vol. XII, No. 4.) Price, R. 1-4 or 2*s.*

Bulletins.

2. Bee-keeping, by C. C. Ghosh, B.A. (Pusa Bulletin 46 ; Second Edition.) Price, Rs. 2.
3. The Prevention of Nuisances Caused by the Parboiling of Paddy, by J. Charlton, M.Sc., A.I.C. (Pusa Bulletin 146.) Price, As. 5.
4. List of Publications on Indian Entomology, 1922 (compiled by the Imperial Entomologist). (Pusa Bulletin 147.) Price, As. 7.
5. The Relative Responsibility of Physical Heat and Micro-organisms for the Hot Weather Rotting of Potatoes in Western India, by S. L. Ajrekar, B.A., and J. D. Ranadive, B.Ag. (Pusa Bulletin 148.) Price, As. 5.
6. A Study of the Factors Operative in the Value of Green Manure, by P. E. Lander, M.A., D.Sc., A.I.C., I.A.S. ; B. H. Wilsdon, M.A., I.E.S. ; and M. Mukund Lal, L.Ag. (Pusa Bulletin 149.) Price, As. 5.

Reports.

7. Review of Agricultural Operations in India, 1922-23. Price, R. 1-10.
8. Proceedings of the Second Meeting of Veterinary Officers in India held at Calcutta from 26th February to 2nd March, 1923 (with appendices). Price, R. 1-12.

THE WEAVER-BIRD OR BAYA (*PLOCEUS PHILIPPINUS*).

Original Articles

SOME COMMON INDIAN BIRDS.

No. 28. THE WEAVER-BIRD OR BAYA (*PLOCEUS PHILIPPINUS*).

BY

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AND

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The Tailor-bird has already afforded us an example of admirable nest-building and the Weaver-bird has equal claims for admission to our circle of bird friends, which, so far as this series is concerned, must be strictly limited. We may, however, at once note a point of contrast between the two. The Tailor-bird makes every effort to escape its enemies by concealing its nest between leaves sewn together ; the Weaver-bird, on the other hand, positively flaunts its nesting arrangements before our eyes and in many parts of India its nests—whole colonies of them, indeed—form conspicuous objects of the country-side. In some places scores of these nests may be seen, freely exposed to view, hanging from favourite trees, which are usually palms or *babuls* (*Acacia arabica*), trees which overhang water often being selected as it seems to be a *sine quâ non* that the situation considered suitable for suspending a Weaver-bird's nest should have no other tree directly underneath it which might afford access to enemies from below. For a nest swinging up aloft on the tip of a long slender palm-shaft is singularly inaccessible to most would-be marauders.

Although the nests are familiar enough, the bird which constructs them is less so. The Weaver-bird belongs to the large family of the Finches and at most times of the year looks very like a hen House-sparrow, being a small, thick-billed, reddish-brown bird. Towards the beginning of the Rains, however, the cock bird dons his breeding plumage, his head, neck and breast becoming a beautiful golden-yellow and his chin turning almost black.

With the onset of the Rains, nest-building commences, either a new nest being built or an old one, of the previous season, patched up and put into good repair. The process of patching up old nests, which are easily distinguishable by the difference in the colour of the grass, and building new ones can often be seen going on in the same tree. The nest itself is strongly woven with strips of leaves of grasses, plantain or palms, strips from leaves of wild species of *Saccharum* being used most commonly. These strips are prepared by the bird itself, which seizes a leaf in its beak and makes a notch at the edge near the base of the leaf; it then grips with its beak the edge of the leaf above the notch and jerks its head away so as to tear off a strip along the edge of the leaf; by flying off with the end of this strip in its beak, the strip is usually pulled off along the length of the leaf; but sometimes, at the first effort, if the leaf is tough, the bird is pulled backwards and hangs suspended by the strip in its beak, so that several attempts have to be made to detach the strip required for nest building. Sometimes the bird bites a second notch on the edge above the first and at a distance allowing for the length of strip which it considers necessary. The strips thus collected are wound securely around the branch or leaf from which the nest is to be suspended and, as more strips are brought in, these are added, securely wound and plaited together, until there is formed a long stalk from which the nest proper is suspended. This stalk is usually about four or five inches long but may occasionally extend to as much as a foot. Having completed the suspensory stalk, the birds then expand its lower end into a bulb-shaped structure, which is usually about five and a half inches in diameter in one direction and four inches in the other. At this time, having determined where the egg-chamber is to be, the birds construct a strong transverse

bar or loop, a little to one side of the centre of the chamber, this bar forming a division between the egg-chamber and the long tubular entrance. At this stage of construction the nest resembles an upturned basket, the loop representing the handle. Up to this point in the construction of the nest, both sexes have done the same kind of work in collecting fibre-strips and weaving these into the nest, but, when this loop has been completed, the female bird takes up her position on it, leaving the cock henceforth to procure more material for building and to work from the outside of the nest, whilst she works from the inside, both of them pushing and drawing in the fibres through the walls of the nest so that everything is plaited together smoothly. The little builders seem to enjoy themselves thoroughly, the cock bird especially being industrious, emitting a cry of delight each time that he brings in a beak-full of fibre and often bursting into song during the process of weaving material into the nest. The egg-chamber is now finished on one side of the loop and on the other side the walls of the nest are prolonged downwards into a long tubular entrance, about two inches in diameter internally, and usually about six inches long, but occasionally twice this length. The male bird often continues building on to this tubular entrance even after the eggs have been laid and are being incubated by the female. The lower end of the tubular entrance is loosely woven so as not to afford any firm support to enemies attempting to plunder the nest. The birds themselves when entering the nest close their wings and shoot perpendicularly upwards through the tube; it is marvellous how they can do this without running their heads through the top of the egg-chamber or even apparently shaking the nest. This tubular passage is used as an entrance to the nest by the parents whilst nest-building and incubation are proceeding; but, when the eggs have hatched, the food brought to the nestlings is passed in to them through small holes pierced through the sides of the egg-chamber. The presence of such holes is a sure sign that the eggs have hatched.

It will now be apparent what a hard nut has to be cracked by any would-be plunderer of the nest, which is placed high up out of reach of any non-climbing animals. Even a good climber,

such as a squirrel, rat, snake or lizard, will find little to cling to on the tip of a palm-leaf and, arrived there, has to negotiate a distance of at least eighteen inches to reach the entrance to the nest, whilst the lower portion of the entrance-tube is too flimsily constructed to yield any foothold. Plainly visible, its inaccessibility is its sure defence and it can well defy most marauders.

There is still one point to be mentioned about these nests and that concerns the lumps of clay which are stuck onto them in odd places. Jerdon notes that he found in one nest about three ounces of clay in six different places. Many theories have been advanced in explanation, a very popular idea in India being that the bird uses these clay patches as *points d'appui* on which to stick glow-worms to illuminate the interior of its nest. A more probable explanation is that the clay is applied to balance the nest more correctly, to prevent it being blown about by every gust of wind and to keep it steady whilst the birds are entering and leaving it.

Two is the normal number of eggs laid but occasionally three or four are found. As many as ten have been noted, but, in cases where there are so many, they are probably the product of more than one bird. The eggs are usually found in July and August. They are pure white in colour, without any gloss, typically rather long ovals considerably pointed towards the smaller end, and measure about 20 by 15 millimetres.

The Baya is found throughout India and is now divided into four subspecies, which are the Baya (*Ploceus philippinus philippinus*) found in Ceylon and the greater part of India ; Finn's Baya (*P. philippinus megarhynchus*), a local race found in the Himalayas about Nainital ; the Eastern Baya (*P. philippinus passerinus*). found in the lower Himalayas and Hills in Bengal, Assam, North Burma and Siam ; and the Malayan Baya (*P. philippinus infortunatus*) which occurs in the Malaya Peninsula and Siam, only entering our limits in Tenasserim. It is the typical race which is shown on our Plate. Besides the Baya, three other species of Weaver-birds are found in India, of which the Indian Striated Weaver-bird (*Ploceus manyar flaviceps*) has the feathers of the breast streaked longitudinally with black ; this bird is not uncommon in localities

in Northern India providing suitable rushy, reedy cover, in which the nests are placed, the nests being much like those of the Baya but without the long pensile support.

Like most of its relatives, the Weaver-bird is largely graminivorous, feeding on seeds of grass, paddy, millets, and weeds, but a certain proportion of insect food, mostly small beetles and caterpillars, is taken. It cannot be claimed as a useful bird, and during times of forest fires the nests sometimes burn through at the base and may then be blown, all ablaze, for hundreds of yards into areas which would otherwise escape from the fire.

Its feeding habits make it comparatively easy to keep the Baya as a cage-bird and it is often so kept, young birds being offered for sale in Calcutta during August. Given a large enough space, the Baya will weave its wonderful nest in confinement, but requires all the space for itself for, as Cunningham remarks, " they are very undesirable additions to any aviary containing other kinds of small birds, as they are very aggressive, and are possessed by a deeply-rooted desire to hammer in the skulls of their neighbours, which, as Abdur Rahman in his autobiography remarks of a Baluchi tribe of similar disposition, ' naturally causes disputes ' ".

Young Bayas are readily tamed and easily acquire tricks, such as threading beads, drawing up little buckets of water or of seed, or loading and firing off a toy cannon. Lockwood Kipling tells of one which flew up to a tree at the word of command, selected a flower or leaf, plucked it, and, returning, placed it daintily between its master's lips. There is no doubt that it is an intelligent bird and it is therefore a favourite cage-bird. In the Punjab a popular proverbial rhyme contrasts the house-building talents of the Weaver-bird with the helplessness of the shelterless monkey which cannot protect itself against the weather in spite of possessing human hands and feet. " This verse," says our informant, " is often quoted for the benefit of idle boys and girls who object to learn," much in the same way as the little busy bee is held up for infantile admiration in Western lands.

FUTURE DEVELOPMENT OF COTTON-GROWING IN INDIA.*

BY

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Secretary, Indian Central Cotton Committee.

It is my privilege to-day to welcome the members of the Agricultural Section of the Science Congress, and to say how greatly I appreciate the honour of being allowed to preside over this Section. I trust that our meeting this year will maintain the high standard attained in previous years.

It has been a custom amongst my distinguished predecessors to select for the presidential address some general question connected with agricultural development. I propose to-day to depart from that precedent and to invite you to consider agricultural research in its relation to a particular crop, viz., cotton. My reasons for this are three: In the first place, much of my time in recent years has been devoted almost entirely to this crop. Secondly, in the Central Cotton Committee India now possesses a unique organization for the furtherance of the improvement of the cotton-growing industry; an organization, moreover, which not only is representative in character but which possesses funds of its own and thus able to provide the means for giving effect to many of its own recommendations. Thirdly, bearing in mind that agriculture is in the first place a business and in the second place an art, it occurs to me that it may be of no small profit to ignore momentarily the conventional division of science and to examine briefly the

* Presidential address at the Agricultural Section of the Indian Science Congress, Bangalore, 1924.

problems presented in attempting the improvement of a single crop. To agricultural improvement every pure science has contributed and will contribute in future. A science of agriculture can hardly be said to have arisen as yet, but the supreme importance of the scientific method in agricultural work is now realized. If the problems requiring solution lie on the borders of several pure sciences they are the more fascinating for that very reason, and, as in other branches of applied science, the thorough investigation of the economic side of our problem must be provided for.

The cotton-growing industry in India occupies a position which in many respects is unique. It is true that the area under cotton is much smaller than that under food crops, nevertheless India is the second cotton-growing country in the world. Further than this, approximately half of the cotton grown in India is converted into yarn and cloth in the country. Not only is India the leading cotton-spinning country in the East but she is the fifth cotton-spinning country in the world. But, though the cotton spinning and weaving industry is the most important in India, cotton is still one of our most important exports. Thus, in addition to the actual cotton-growers, no small proportion of the population is concerned with cotton trade or cotton manufacture, and, apart from the production of the essential food-grains, there is probably no other crop with which the welfare of the country is so intimately connected. As a principal constituent of clothing, especially of cheap clothing, cotton is of intense importance to the world generally and particularly to the agricultural classes of India and the East. The world position in regard to the production of this most important staple is at present extremely unsatisfactory. The prices of most agricultural products have now approached to pre-war values, but cotton, a raw material of outstanding importance, still stands at well over double pre-war prices. This position is liable to be intensified when the cotton mills of Europe attempt to attain pre-war production. At present, cotton mills throughout the world are working much below their full capacity, largely for the reason that high prices have limited consumption. Those high prices have been brought about chiefly by under-production of the raw material. The reduction of the American

crop has been attributed to various factors. Enhanced cost of production and a rise in the cost of labour have undoubtedly been contributing causes, but the real cause has been the damage done by a single insect pest, the dreaded Mexican Boll-Weevil, which despite all efforts to check its advance has now spread throughout the American cotton belt. The areas sown with cotton in America during the last two years have been well above the average and the present area resulting from the stimulus of high prices is practically a record. But the yield per acre is again most unsatisfactory, and from an area of some 38 million acres, which a few years ago produced 16 million bales and even in unfavourable years has produced 13 million bales, only a crop of 10 million bales or so is now expected. At an optimistic estimate the average production of cotton in America has fallen by 2-3 million bales per annum, an amount equal to more than half of the total Indian crop. Despite years of patient scientific endeavour and the application of control measures on a scale which has never been attempted in any other country and at almost fabulous cost, no real solution of the difficulty has been found. Methods of poisoning, especially with calcium arsenate, have been developed which will reduce the loss but at considerable cost, and there seems little hope that this method of control can be universally applied. Even where it has been successful the expense has been great, amounting to anything from 1*d.* to 2½*d.* per lb. of the cotton produced. An even more serious consideration is that under weevil conditions cotton-growing threatens to become unprofitable in a considerable portion of the American cotton belt, thus suggesting further reduction in cotton production. The conclusion is obvious, viz., that unless other parts of the world can increase their production of cotton, especially of cotton of certain types, the clothing supply of the world will be restricted for years to come.

Increased cotton production in India has often been urged and is undoubtedly possible, but it is desirable to recognize frankly what our limitations are. India, in certain respects, is a fully developed country with a dense population and consequently with only limited opportunity for increasing the *area* under any particular

crop. Direct increases in the cotton area have been possible in recent years by the extension of canal irrigation. The creation of canal colonies in the Punjab not only added 800,000 acres to the cotton area (and some 300,000 bales in yield), but has made possible the cultivation of half a million acres of long staple cotton. The Sukkur Barrage and canal scheme in Sind will probably enable an equally important advance to be made during the next ten years, but I must not dwell on this point as it forms the subject of a paper by Mr. Main. For the time being at any rate we have probably reached the limit of direct additions to the cotton-growing area. Any other additions must be at the expense of other crops. The area under cotton in India does respond directly to enhanced prices and has done so in recent years, but in many respects the cultivator is not a free agent. Not only does a dense population necessitate a large area under food crops and under fodder crops to support a large, though inefficient, cattle population, but the fact that holdings are small militates against the maximum area being devoted to the so-called commercial crops.

It is unnecessary in an assembly of agriculturists to lay stress on the need for rotations. It is now widely recognized that existing rotations in India are based in most cases on sound economic and practical considerations and are not readily disturbed. It is, therefore, to higher agricultural yields that we must look for the principal solution of our problem, not only higher cotton yields but better yields from all crops and a higher agricultural efficiency all round, thus releasing land for increased areas of revenue producing crops.

It is common knowledge that like other crops cotton is dependent largely on the vagaries of the monsoon. I should not have considered it necessary to refer to this but for the fact that the effect of the monsoon on the cotton area, as distinct from yield, is not always recognized. I am indebted to Dr. Leake, Director of Agriculture, United Provinces, for some figures which clearly illustrate this point. Approximately one-third of the cotton of the United Provinces is grown on canal irrigation, and he has shown that in recent years this area has been almost directly governed

by the relation between the prices of cotton and wheat, the correlation factor being high and positive, viz., 0·57 (± 0·11). For the un-irrigated cotton area the contrary is the case, the area sown being almost directly determined by the nature of the monsoon prior to the middle of July, the correlation factor between rainfall prior to 15th July and the cotton area being 0·62 (± 0·11). If we except the canal-irrigated tracts of Northern India, a relation similar to the latter may be said to hold fairly generally. Fluctuations in area through conditions beyond the control of the grower must therefore be expected. The effect of the monsoon on yield is too well known to need emphasizing.

The problem before the Agricultural Departments, therefore, is not an increase in area but an increase in the profits obtainable from cotton production. Every advance in this direction tends to be reflected in the area and is directly reflected in production. It is necessary to state most clearly, however, that the mere increase in the quantity of cotton produced, though important in itself, is not the real objective. If India is to assist to her own profit in meeting the present world's shortage, it is essential that she should produce more of the type of cotton which the world requires. It has already been stated that India is the second cotton-producing country in the world. Her average cotton crop is approximately 5 million bales equivalent to 4 million American (500 lb.) bales as compared to an American crop of some 10 million bales. But 70 per cent. of her cotton is of so short a staple that it can only be used to a limited extent. The cotton spinning and weaving industries of the world have developed mainly on the basis of the type of cotton which America has supplied in the past, i.e., cotton of not less than $\frac{7}{8}''$ staple. At least 30 per cent. of the Indian cotton crop is of only $\frac{5}{8}''$ staple and 70 per cent. is below $\frac{7}{8}.''$ India exports well over a million bales annually of these very short staple cottons, and there is no indication that the world's spindles can use very much more of this quality. On the other hand, Indian mills absorb something like half of our average commercial crop, and out of the 2-2$\frac{1}{4}$ million bales which they use, over one million bales are of staple cotton, i.e., cotton of $\frac{7}{8}''$ and upwards. Of such cottons

there is only a small margin estimated at an average of some 250,000–300,000 bales per year. Incidentally in certain years the imports of American cotton into India have been as high as 100,000 bales and there is a regular import of similar cotton from Africa.

In the past India has occasionally experienced difficulty in selling promptly the whole of her crop in a year of large production. e.g., when in 1919-20 an Indian crop of nearly 6 million bales coincided with a fair crop of American cotton, resulting in a carry-over on 31st August, 1920, of over a million bales in Bombay alone and exclusive of mill stocks. The crop in the following year fell below 4 million bales, thus relieving the situation. But it is clear that our percentage of short staple cotton is unhealthily high. It will be obvious that our ultimate objective should be to enable the Indian cotton cultivator to produce a cotton which will be freely competed for in the world's markets every year; at present this is not the case. At the present moment while American cotton is selling at some 20*d.* per lb., Indian short staple cotton is fetching only about nine annas per lb. I have dwelt on this question at some length because it has often been urged in the past, and from authoritative quarters, that India should produce more cotton whatever the quality may be. The truth appears to be that even with the present world's shortage there is only a limited demand for cotton of less than $\frac{7}{8}''$ in staple.

As is well-known, India at one time produced a larger proportion of stapled cottons than at present. Within recent history, for example, the Central Provinces and Berar grew chiefly Bani cotton (*G. indicum*)—a cotton of one inch staple and over and one of the best of our indigenous cottons—instead of the short staple cotton which now forms the bulk of the crop. The irony of the situation lies in the fact that it is largely the development of cotton spinning with modern machinery in the East which has led to the replacement of long by short staple cottons. Indian mills and China and Japan are by far the most important outlet for short staple cottons although the demand from the Continent is by no means unimportant.

Such cottons as Bani are characterized by a low ratio of fibre to seed and in most tracts by a relatively low yield per acre. Until cotton marketing in India reaches a much higher standard of perfection than we can foresee at present, only in very rare cases, if ever, could an Agricultural Department advise the substitution of a high quality cotton of low average yield for an existing variety of higher yield.

The ratio of cotton lint to seed or the ginning percentage, as it is commonly called, is also an extremely important though not the critical factor. In most parts of India the cultivator sells unginned cotton, i.e., *kapas*, and in consequence, so far as he is concerned, ginning percentage is only one of the commercial qualities of *kapas* and therefore capable of being set off by lint quality, provided that the necessary primary market facilities can be established. The ideal cotton for any tract would be one with growing period adapted to local climatic conditions, equal or superior in yield to the present varieties, equal to them in ginning percentage and with a staple of *at least* $\frac{7}{8}''$ and preferably over 1″. Such an ideal is not impracticable, but the difficulties to be overcome in its attainment vary greatly in different tracts. The three means at our disposal to securing this end are :—

(1) The isolation of the best unit species from the existing mixed crop.

(2) The use of an acclimatized exotic often involving irrigation facilities and, for complete success, involving the isolation of pure lines.

(3) Hybridization.

In those areas which already grow cottons of relatively long staple, the first method has already given excellent results. In the Tinnevelly tract the isolation of the Karunganni constituent from the crop has given a cotton of superior staple and better yield. The same is true of the Westerns and Northerns tracts. In South Gujarat the deterioration due to the invasion of this area by a short staple *herbaceum* cotton of high ginning percentage has been checked by the isolation and establishment, over practically the whole of the Surat District and a considerable portion of the

Baroda State, of a longer staple unit type. In Dharwar, success has been attained by the isolation of pure types from Kumpta and Dharwar-American cottons. The latter incidentally is an acclimatized exotic American of ancient origin.

The second method has met with conspicuous success in the Punjab and in Madras, in both cases a short staple cotton having been replaced by a long staple cotton. Punjab-American, which is now grown on half a million acres, is a selection from Upland American introduced originally into Bombay over fifty years ago. Cambodia cotton, now grown throughout the Coimbatore and parts of other districts in Madras, is an American type obtained from Indo-China. In both these cases success has been possible by the development of these cottons as an irrigated crop. The success of Cambodia is of particular interest as the irrigation is from wells, and the cultivation intensive, comparable with that given to garden crops.

In the Central Provinces and Berar and in the United Provinces where the existing cottons are of very short staple, the material for selecting a type of $\frac{7}{8}''$-$1''$ staple probably does not exist. With canal irrigation part of the United Provinces can grow an acclimatized Upland American cotton successfully, but in the greater part of the province a cotton of short vegetative period comparable with the existing *neglectum* type is an essential. The same appears to be true of the Central Provinces, Berar and the Khandesh Division of Bombay. In these tracts pure line selection has produced types more profitable to the grower, for the time being at any rate, than the previous mixture, but the real problem has not been solved. In such areas ultimate success will probably only be achieved by hybridization, although it is not possible to be too emphatic on this point.

It is by no means certain that we have yet reached a limit in the improvement of cotton by the study of the unit species contained in the present mixtures. The importance of such work cannot be over-rated, for it not only provides material for temporary advances in the desired direction, but is essential to a proper understanding of the material available even if the final solution can only be found by hybridization.

There are still some gaps in our knowledge of the inheritance and characters of cotton, particularly of those determining its commercial value. The work of Leake, and later of Kottur, Patel, Hilson and others, has done much to clear up many of the points which seemed obscure. But even now we are still ignorant of some of the factors determining the agricultural yield and as to whether there is anything in the nature of a linkage between staple length and the lint-seed ratio. Within any given agricultural variety there is undoubtedly a general tendency for long lint to be accompanied by a low proportion of lint and for short lint to be accompanied by a high ginning percentage. It is fairly clear that no complete linkage exists, but there are probably limitations on the extent to which the two can be combined. Fuller knowledge on this question is clearly of great importance.

Physiological research is also needed to elucidate the present low yield of many types of cotton, particularly in the black soil areas. No less is it needed to elucidate the causes for the loss of crop caused by bud and boll shedding. Preliminary work in Bombay and Madras has shown that the latter offers a most fruitful field of enquiry.

To multiply such instances would be tedious. The work of the Agricultural Departments has already added enormously to the profits of the cotton-grower, and if the problems which await solution before a further advance can be made demand time and patience, we can go forward with the knowledge that the scientific results achieved can undoubtedly be given effect to in the general cotton cultivation of the country through the organization which the Departments of Agriculture have built up.

It was my privilege last year to contribute a short paper to this section dealing with the necessity for technological research on raw materials with special reference to cotton. I was able to show then that the task of the agricultural investigator concerned with cotton improvement is in some respects rendered unnecessarily difficult by the lack of knowledge as to the precise qualities in cottons which are desired by the spinner, and by lack of facilities for testing new cottons.

Textile physics is a comparatively new branch of the subject, but has already led to very valuable results in England where investigations now being carried out to elucidate the constitution and character of the cotton fibre may eventually lead to marked and possibly revolutionary changes in spinning methods. There is a wide field for such work in India, especially if directed to the improvement of the raw material. I shall refer again to this subject later.

No less important than agricultural research and improvement is the improvement of cotton marketing, the object being to obtain for the grower the fullest possible price for the cotton he produces. The possibility of introducing certain improvements into general agricultural practice will depend largely on such market organization. It is not sufficient that the major markets are willing to pay enhanced prices for superior staple or for clean cotton. This premium must reach the grower. For this to be the case two conditions must be fulfilled. Firstly, many of the present gross forms of adulteration, resulting as they do in small profits to the middleman, out of all proportion to the loss caused to the producer and to the general economic loss to the country, must be stopped. Certain Indian cottons for many years have possessed an unenviable reputation on account of the mixing of different varieties much of which is deliberate and fraudulent mixing. Secondly, the organization of primary markets requires improvement to bring them into better touch with major markets and to give the grower a square deal. Nor can the major markets for Indian cotton be held to be entirely satisfactory. The classification adopted, based as it is on geographical distinctions and station names rather than on intrinsic quality, does not tend to the grower getting the full value of his cotton. Again, since the whole question of agricultural finance is involved, the possibility of developing co-operative methods of marketing may well be a critical factor. It will be seen, therefore, that the question of cotton improvement covers an extremely wide range both scientifically and commercially. Until comparatively recently the Agricultural Departments were left to deal with these various phases almost unaided.

As one of the results of the touring Cotton Committee of 1917-18, the Indian Central Cotton Committee was created in 1921 and permanently incorporated with funds of its own in 1923. This Committee consists of representatives of cotton growers, cotton traders, cotton spinners, cotton ginners, of the Agricultural Departments of the cotton-growing provinces, and representatives of the larger cotton-growing Indian States. The cotton cess, on which the Committee depends for its funds, at present produces some Rs. 9,00,000 per annum, the great portion of which is devoted to the furthering of research.

By means of research grants to Provincial Departments of Agriculture the Committee has been able to make provision for additional research on problems of general applicability. In the Bombay Presidency grants have been given for physiological research in connection with boll and bud shedding, research on cotton wilt, investigations in the methods of dealing with spotted cotton bollworm and for plant-breeding work on Upland cotton. In Madras, a grant has been given for special investigations on the *herbaceum* cottons of the Northerns tract and a further grant sanctioned for bio-chemical research on the causes of resistance and susceptibility to disease and the effect of environment on the staple.

In the Central Provinces, grants have been given to enable a more thorough study of the cottons of the province and for work on cotton wilt. In the United Provinces, a grant has been given for special investigations on the pink bollworm. In the Punjab, provision has been made for a special study of Upland American cottons under canal colony conditions. Other research schemes are under consideration. In addition, the Committee proposes to provide for a Central Agricultural Research Institute for cotton, to be situated in Central India, for both plant-breeding and physiological investigations.

I have already referred to the importance of technological research, and provision for this has been made in the Central Technological Laboratory, Bombay, which will shortly be completed. It is a matter for regret that Professor Turner, of the

Manchester College of Technology, who has recently been appointed Director of this research Laboratory, arrives in India just too late to be with us to-day. In the course of a few months we shall be able to offer agricultural investigators the fullest facilities for the testing of new cottons, and a start will be made on a general technological study of Indian cottons.

On the economic side, and in its capacity as an advisory Committee, the Central Cotton Committee has taken up actively the question of checking adulteration and the improvement of marketing at all stages. Certain of its recommendations for legislation have already been given effect to by Government and others are still under consideration. In particular the Cotton Transport Act passed a year ago enables any Local Government to prevent the importation into tracts growing superior cottons of inferior cottons for purposes of mixing. This Act is already in force in the Bombay Presidency.

Time does not permit of even a casual review of the Committee's various operations. But, apart from its more formal activities, its value as a common meeting ground for all sections of the cotton industry has already proved to be of the greatest value.

It will be seen that the Central Cotton Committee is trying to do for India the work which the Empire Cotton Growing Corporation is attempting for the British Empire as a whole, but with special reference to the newer cotton-growing countries. It marks a new departure in the development of Indian industries, for it is a body composed mainly of unofficials administering funds contributed by the cotton trade and industry for the improvement of that industry. It has initiated a well-balanced and adequately financed programme of research work and, during the two years of its existence, has made very important progress towards the solution of the many problems which the improvement of cotton-growing in India involves. Not only has the industry itself provided funds for its own improvement, but individual representatives of its various branches, gentlemen occupying important positions in the commercial world, have given unstintedly of their time and thought. Team work of this nature, where all interested in the improvement of

cotton pull together, cannot fail to be of the greatest value. The Committee has fully justified the confidence which the Government of India and the Indian Legislature reposed in it when in January last the Committee was given a definite constitution and permanently incorporated by a special Act.

In conclusion, I would venture to remind you of the stress laid by two past Presidents of this Section on two important aspects of agricultural work. In 1918, Dr. Coleman urged the necessity for accuracy in agricultural investigations and for accurate field experiments. In 1921, Mr. Milligan drew attention to the many-sided nature of the problems with which the agricultural investigator is confronted and urged the desirability of more team work directed to the solution of a particular problem or group of problems. Not only in respect of the crop which we have been discussing but in regard to all agricultural investigations in India, there was perhaps never a time when these two maxims stood so much in need of emphasis. Now that every Agricultural Department is busily engaged in developing the successful results of earlier experimental work, there is no small danger that, during a period of financial stringency, the necessity of adequate provision for further research and experiment may be overlooked or discounted. On the other hand, the next advances in agricultural improvement may only be achieved after much patient and laborious investigation, for in many instances we have only just come to grips with the essential features of our major problems.

Superficial or inadequately conducted experiments are no more justifiable in applied science than in the pure sciences. Only by patient and co-ordinated effort are lasting results likely to be achieved.

THE JAMSHEDPUR SEWAGE DISPOSAL WORKS.

THE JAMSHEDPUR ACTIVATED SLUDGE SEWAGE DISPOSAL WORKS.

BY

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AND

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When the town of Jamshedpur or Sakchi, as it was then called, was first built, it was laid out to accommodate about 8,000 to 10,000 workmen, which were sufficient to supply the needs of the Tata Iron and Steel Works, as they were originally planned. With the extension of the Works the town has grown until there is a population of more than 50,000 situated near the Steel Works.

The sewage of the original town was disposed of in two septic tank installations which were quite adequate and entirely satisfactory. The effluent from these septic tanks ran down *nalas* and ultimately found its way into the rivers which embrace the town on two sides. The purification was so far complete that sewage contamination could only be traced a very short distance down from the points at which the effluents entered the rivers.

In the latter half of 1916, the Company realized that, in view of the expected extensions of the town and works, competent advice should be taken to ensure satisfactory drainage and sanitation of the town. For this purpose Lt.-Col. Clemesha, M.D., M.R.C.S., D.P.H., I.M.S., Sanitary Commissioner to the Government of India, was consulted and he made a report, in the course of which he advised that a new method of treating sewage, namely, the activated sludge process, had been discovered, and that it was more satisfactory than septic tanks for many reasons. In 1918, Dr. Gilbert J. Fowler, D.Sc., F.I.C., of the Indian Institute of Science,

Bangalore, was consulted, and he explained the advantages offered by the activated sludge system of disposal inasmuch as it claimed to produce a clear non-putrefactive effluent and a sludge rich in nitrogen and free from any offensive odour and thus valuable as a fertilizer. At that time there was no activated sludge plant working in India and doubts were raised regarding the suitability of the process for this country. A series of laboratory experiments were inaugurated at Bangalore under the supervision of Dr. Fowler, who took an active part in the original experiments and in the original design of the activated sludge plant. These experiments clearly demonstrated the feasibility of working the process on a small scale, and it was decided to deal with the sewage of an additional part of the town, which had to be cared for immediately, in an activated sludge plant, which would form a practical disposal works for that part of the town, provided the process was a success, and an experimental station for determining the design of the enlarged plant necessary to take care of the whole town.

Conditions were such that it was necessary to pump the sewage either before or after it passed through the disposal works. A pumping station was, therefore, erected consisting of a well calculated to contain about 12 hours' flow of sewage, which would be a safeguard if there should be a temporary stoppage of the pumps, and designed to act as a grit catcher, and a pump chamber containing two stereophagus pumps delivering into a 7-in. cast iron rising main 6,214 feet long leading to the site selected for the disposal works. This site, which is on the summit of a ridge, was chosen because it commands for gravity irrigation an area of about 1,000 acres of arable land.

From the gaugings made in existing sewers and surface drains it was estimated that the quantity of sewage to be dealt with daily would be 120,000 gallons from some 3,000 persons. The activated sludge plant was constructed to designs prepared by Activated Sludge, Ltd., nominally capable of handling up to 150,000 gallons per day, for 3,000 persons at 50 gallons per head. It consists of three aeration tanks, all leading out of and back into a bye-pass channel, a settling tank, a sludge re-aeration tank and blower house

containing two blowers. The total capacity of the tanks is 150,000 gallons. When serving 3,000 persons, therefore, the tank capacity is about 2 c.ft. per head.

The tanks are constructed of masonry work and are built above ground-level, as both the effluent and sludge are used for irrigation, and it was desirable to retain as much "head" as possible. The bottom of the settling tank is hopper-shaped and below ground-level. From the bottom of the hopper an air-lift leads into the re-aeration tank. The incoming sewage is admitted at the point where the re-aerated sludge falls into the head of the bye-pass channel. By means of the bye-pass channel the aeration tanks can be used all three together, or either one or two can be isolated. The tank works only on a continuous-flow system, the amount of effluent overflowing at the end depending on the amount of fresh sewage pumped in.

When working at the rate of 150,000 gallons per day and when there is approximately 20 per cent. of sludge accumulated in the tank the detention period is about 5 hours.

The air equipment consists of two rotary blowers which were intended to be driven by electric motors, but owing to delay in obtaining current, are driven temporarily by an oil engine and a portable steam engine. The air is distributed by means of cast iron pipes laid on the walls leading to diffusers supplied by the Activated Sludge Co. The diffusers are laid in shallow troughs in the bottom of the aeration and re-aeration tanks.

The plant was first put into operation towards the end of November 1921. The characteristic activated sludge action was visible in the tank at the end of 24 hours, and after 48 hours' aeration the sludge could be distinctly settled out in a bottle leaving a clear effluent with the following analysis in parts per 100,000:—

	F. S. N.	Alb. N	Nitrite	Nitrate	Cl	Sludge
0 hrs.	0·744	0·216	nil	nil	2·0	nil
24 "	0·860	0·186	nil	f. traces	2·1	f. traces
48 "	0·912	0·108	f. traces	0·01	2·1	distinct

Various difficulties and defects, which were only to be expected in the first plant of the kind to be set to work in India, appeared from time to time. These were dealt with as they appeared and the plant settled down to a satisfactory running after 2 or 3 months. In October 1922, the plant was unavoidably shut down over a month owing to outside causes. Before starting it up again the opportunity was taken to remodel certain parts with the result that the capacity of the plant has been increased to over 200,000 gallons per day.

As a method of purifying sewage the plant has been extremely successful. It has not given rise to any nuisance and has consistently turned out a non-putrefactive effluent. Typical analyses are as follows :—

Crude sewage analysis.

Parts per 100,000.

O_2 abs in 4 hrs.	F. S. N.	Alb. N	Nitrite	Nitrate	Cl	Kjeldhal (N)
11·26 ..	1·6068	0·420	nil	nil	3·2	3·22
11·26 ..	1·8852	1·980	nil	nil	3·5	9·24
13·80 ..	2·6656	2·100	nil	nil	4·0	9·80

Analysis of effluent.

Parts per 100,000.

O_2 abs in 4 hrs.	F. S. N.	Alb. N	Nitrite	Nitrate	Cl	Kjeldhal (N)
0·68 ..	1·014	0·120	nil	0·008	2·6	6·3
0·64 ..	1·301	0·105	f. traces	0·006	2·6	2·5
0·70 ..	1·440	0·125	0·02	0·007	2·4	2·1

Analysis of sludge dried in the sun.

	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
Moisture ..	6·0	9·08	6·9	4·86	1·00	4·84
Organic matter ..	72·5	70·52	69·8	72·08	75·78	62·52
Ash (mineral matter)	21·5	20·40	23·2	23·05	23·21	32·63
Nitrogen by Kjeldhal	7·6	8·88, 9·13	7·84	8·73	8·62	6·18
	$P_2O_5=1·35$, $P_2O_5=1·66$, $P_2O_5=1·59$	$K_2O=0·25$ per cent. Ether soluble matter=5·5 per cent.				

During one period of accurate observation the number of persons served was 6,000. The flow of sewage was 150,000 gallons per day. The dilution of the sewage was, therefore, 25 gallons per head per day, and the cubic capacity of the tank 1·3 c.ft. per head. With the plant working under these conditions, an entirely satisfactory non-putrefactive effluent was obtained, and a sludge which could be handled without difficulty. At times the flow of sewage has risen as high as 240,000 gallons per day and the population served may have been as high as 8,000, though this is uncertain. When the flow is as great as this, the settling tank capacity is not sufficient to bring down all the sludge, and light particles are to be seen in the effluent, but no trouble has yet arisen on this account. Ever since the plant was put into operation the whole of the effluent and sludge produced by the plant has been absorbed in the farm lands.

Some experiments were made on drying the sludge in the sun. It was found to dry very well on turf provided the depth of the sludge layer did not exceed 3 in. Drying on sand was found unsuitable because although the sludge dried more rapidly, it penetrated the upper layers of the sand which became incorporated with it, thereby lowering the percentage of nitrogen per volume of dry sludge. A 3 in. layer of sludge on turf dries to spadable condition within 6 hours, and within 24 hours it is quite dry in flakes, which can easily be handled. In thin layers it will dry well on a cement floor. The sludge dried in the laboratory both on turf and on the cement surface of a roof, and kept in a stoppered bottle from last year, shows so far no sign of deterioration or of any offensive smell.

The sludge that has been used in cultivation and incorporated in the soil has not so far created any nuisance in the locality.

In addition to the success in purifying sewage, the use of the effluent and sludge for irrigation and fertilizing land has been very successful. Several acres of land which are in the nature of hard gravel (known as moorum) and which were rejected by all the indigenous cultivators as totally barren are slowly changing their texture by constant irrigation with sludge. Organic humus and nitrogen are being supplied by the sludge, and in one particular plot four crops, namely, oats, maize, beans and cabbages, were raised within the period of one year. The yield and growth of various crops such as maize, beans, sugarcane, oats, and market vegetables, such as cabbages, cauli-flowers, brinjals, peas and other varieties, have been quite satisfactory. The sugarcane was grown on good paddy land, the yield being as follows :—

Class of cane	Weight per acre	No. of canes per acre
	lb.	
J 247 (thin)	120,000	51,900
New Guinea 22 (thick)	108,000	27,600
New Guinea 15 (thick)	76,160	15,300

These results were obtained over an area of a little over three acres and may therefore be accepted as practical.

A series of experiments was made to compare the efficiency of sludge as a fertilizer with other natural and artificial fertilizers. A piece of the barren land referred to above was selected and was divided into 10 plots, each of $\frac{1}{40}$th acre.

Five of these plots were irrigated with water supplied from the town mains ; the other five with activated sludge effluent. The plots were manured as shown below. The activated sludge being liquid was distributed by making small channels in the plots. The sludge was dry in a little over 24 hours and when quite dry was mixed with the soil by ploughing. During these operations there was no nuisance of any kind. In plot 8 the sludge was applied on 7th December, 1922, and in plot 7 on 9th December, 1922. Cowdung and ammonium sulphate used in other plots were

applied on 9th December, 1922. As it was late in the season, it was decided not to attempt to grow any crop to its full yield of grain and straw but to be content with green fodder crop. On 16th December, $2\frac{1}{2}$ lb. of oats were sown in each plot.

Within a week the seeds germinated, approximately equally in all the plots. In the third week of January, plots 7 and 8 were looking best of all. No. 1 by this time was very poor. In the second week of February, No. 7 had such a heavy growth that it was thought advisable to cut the plots and conclude the experiments, but before a decision was reached a hailstorm on 10th February, 1923, made it necessary to cut immediately. Results are indicated in the tabular statement given below.

It is worth noting that the mere addition of inorganic nitrogen in plots 2 and 9 did not help the plants as much as the inorganic nitrogen combined with organic manure did in plot 3. This is in agreement with the experiments at Rothamsted farm. Plot 6 is very interesting. It was not manured deliberately in any way, but only irrigated with activated sludge effluent. The most probable explanation is that some sludge, which may have been sticking to the sides of the main irrigation channel, was picked up and carried to the plot by the effluent. Comparing plots 7, 8 and also 6 if the assumption is true, it appears that the activated sludge is easily available to the plants and the more it is added (provided the toxic point is not reached) the better the result. This should be borne in mind when the correct proportion of seed for growing green fodder is being considered. It appears probable that if the quantity of seed in plots 7 and 8 were reduced to half, the individual plants would have thriven better and the ultimate yield would have been as good.

A comparison of the amount of "dry matter" added to plots 7, 8 and 10 is interesting. In plot 7 it is 50 lb. given in 1,000 gallons of sludge. In plot 8 it is only 10 lb. given in 500 gallons of sludge. (The sludge on the latter day happened to contain more moisture and therefore less "dry matter" per unit volume.) In plot 10 it is 560 lb. The farmyard manure in plot 10 has given a fine yield, but it is less than that of plot 8,

where there was only one-fourth of the nitrogen and one-fifty-sixth of the weight of dry matter. This fact would become of great importance if the sludge is ever dried and sold as manure, for the cost of bringing it to the site would be comparatively small.

The experiments are only those of one season, and the figures are those for small plots, $\frac{1}{40}$th of an acre ; but combined with the visible results on the cultivation of some thirty acres, and the satisfactory character and analyses of the effluent from the sanitary point of view, they clearly indicate that the activated sludge system is remarkably well suited to Indian conditions both as a method of sewage purification and as a means of producing a valuable fertilizer.

In order to arrive at some comparison between the cost of sewage disposal by this method and by the method of septic tanks and filters comparative estimates have been made. The activated sludge plant without the prime movers for the blowers costs Rs. 22,100. Such machinery as was available has been adopted for the service, and not being properly proportionate to this work cannot run as economically as the plant should be running. Supposing power was available at a distance of 2,000 ft., the electric wiring and machinery would cost about Rs. 12,500, making a total of Rs. 34,600. The cost of running charges for motors, blowers and all necessary attention to the activated sludge tank would come to about Rs. 2,200 per annum, with power at 2 annas per unit. An alternative method would be to use small oil engines to drive the blowers, the capital cost of which would be about Rs. 6,000, making a total capital cost of Rs. 28,100. The running costs would then be about Rs. 7,000 per annum.

The capital cost of a septic tank and filter installation to turn out an effluent of approximately the same quality would be about Rs. 37,000 and the cost of annual maintenance would be about Rs. 3,200. The annual cost of running the activated sludge plant, if cheap electric current is not available, therefore, is rather more than double the cost of the septic tank and filter plant, but the crops produced by the effluent and sludge of the activated sludge plant will be at least Rs. 4,000 more valuable than the crops produced by the effluent of the septic tank and filters.

For a plant of this size, therefore, it appears that the capital cost and net cost of maintenance are approximately equal. This does not consider any cost of land. The septic tank and filter installation will require an area five times as large as the activated sludge plant.

Experiments with oats manured in different ways.

Plot No.	Area of each plot	Manure per plot	Added nitrogen in lb. per plot	Irrigation	Observation	Height in inches	Yield in lb. per plot of green fodder	Yield in lb. per acre	Yield in units per acre
1	$\frac{1}{40}$ acre	No manure	nil	Water	Growing in thin patches of pale green colour.	14	29 (25-2-1923)*	1,160	1·0
2	Do.	7 lb. ammonium sulphate	1·4	Do.	Do.	16	62 (25-2-1923)	2,480	2·1
3	Do.	Cowdung 140 lb.; ammonium sulphate 3½ lb.	1·4	Do.	Growing well in thick patches of both pale and dark green colour.	17	336 (15-2-1923)	13,440	11·6
4	Do.	Cowdung 280 lb.	1·4	Do.	Growing well like No. 3.	19	194 (14-2-1923)	7,760	6·7
5	Do.	Cowdung 560 lb.	2·8	Do.	Do.	24	222·5 (14-2-1923)	8,900	7·7
6	Do.	No manure	nil	A. S. effluent	Growing well with dark green colour.	21	360·5 (13-2-1923)	14,420	12·4
7	Do.	Activated sludge 1,000 gals.; 50 lb. dry matter	3·5	Do.	Growing very thick with dark green colour, roots deprived of light.	30	762 (13-2-1923)	30,480	26·3
8	Do.	Activated sludge 500 gals.; 10 lb. dry matter	0·7	Do.	Growing thickly with dark green colour, roots deprived of light.	31	449 (12-2-1923)	17,960	15·5
9	Do.	Ammonium sulphate 7 lb.	1·4	Do.	Growing in thin patches.	23	128 (12-2-1923)	5,120	4·4
10	Do.	Cowdung 560 lb.	2·8	Do.	Growing well with dark green colour.	32	410 (12-2-1923)	16,400	14·1

* Date of cutting.

NOTE ON DISEASES OF SHEEP.*

BY

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THIS subject has been suggested for discussion at the Conference, not because the writer has had much experience of sheep diseases, but because he believes that there is a large annual loss of sheep and wool, at any rate in parts of India, much of which could be prevented if (1) more veterinary medical aid were available, (2) the sheep owners would avail themselves of it, and (3) the usual methods of disease control adopted in more advanced countries could be applied.

According to the census of 1914, the number of sheep in the Punjab was 4½ millions; this number had decreased to 4 millions according to the 1919 census. In spite of the very poor grazing usually available in the plains of the Punjab, the number seems extraordinarily small. In the Cape Colony, not much larger than the Punjab, for example, there were over 16 million sheep in 1921.

The small number and decrease may be partly accounted for by extension of canals and consequent decrease in grazing areas, but it seems reasonable to assume that heavy casualties are at least partly responsible. I think our discussion on diseases will support this view.

In passing, with a view to emphasizing the case for more attention for sheep diseases, I would like to point out that sheep in many parts of India, certainly in the Punjab, are valuable animals. They carry wool which has oscillated in value during the past few years between 4 annas and 12 annas per lb. If properly looked after they yield about 4 lb. of wool per year. Assuming 4 million sheep yield only 2 lb. per head at 6 annas per lb., the value is

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30 lakhs of rupees per year. The amount could be doubled if we could control skin diseases.

Mutton in most Punjab cities is now about 6 annas per lb. Punjab sheep in decent condition average about 40 lb. of mutton, so that even at 4 annas per lb. a sheep is worth Rs. 10 to the butcher. If the sheep are well looked after and fed, the mutton is of good quality.

The sheep could easily be graded up to yield much more than 40 lb., but even at Rs. 10 each loss from disease soon runs into large sums of money. The writer has not been able to discover any statistics from which he can give any estimate of the loss by disease. Putting it at the very low estimate of 5 per cent. (it is probably nearer 50), deaths from disease in the Punjab would be 200,000. If half could be prevented, a saving to the province of 10 lakhs of rupees would result.

Internal parasites. So far as the writer's experience goes, the most important disease, or rather parasitic infection of sheep in the Punjab, is infection by *Hæmonchus contortus*, commonly known as the stomach wire worm. Certainly the flock on the Hissar farm has suffered more from this parasite than from any other; this has happened in spite of the fact that Hissar is one of the driest districts in India, the average annual rainfall being under 14 inches. Long periods of drought are common; for example, from 5th August, 1920, till 10th June, 1921, the rainfall amounted to less than one-tenth of an inch. Such conditions must be very uncongenial to the parasite, yet it was found in the stomachs of sheep, the deaths of which were attributed to pneumonia in May and June 1921.

No doubt the presence of canals accounts for its surviving in Hissar. But if it can flourish in Hissar under such adverse conditions, how much more common must it be in other parts of the province and of India where conditions are favourable? Statistics of casualties on the Hissar farm, attributed to the parasite, have not been given, as we invariably treat the flocks as soon as we discover the parasite and they would give no indication of mortality under usual conditions in India. The writer hopes, so far as this farm is concerned, eventually to get rid of the parasite altogether,

by treatment on the lines recommended by the Union of South Africa Veterinary Department.

Several drugs and methods of administration are recommended by the South African authorities. Copper sulphate in solution is the drug the writer generally uses. He has not found it difficult to train men to drench the sheep without untoward results.

In South Africa, *Hæmonchus contortus* is said to cause more losses among sheep and goats than any other internal parasite. The Veterinary Department there has done a great deal of work in connection with it, and has published many valuable papers on it in the "South African Journal of Agriculture."

The next most common parasite at Hissar is *Œsophagostomum columbianum*, the cause of the so-called nodular disease of the intestines of sheep. Considerable losses are attributed to this parasite in South Africa. It is not believed to be the cause of much loss to country-bred sheep in the Punjab. However, pure merinos imported from Australia to Hissar suffered very severely from it, and many died from it. The writer often found portions of the colon almost completely occluded by it. However, very severe lesions were also found in sheep which undoubtedly died from other causes.

During the last four years the average number of sheep on the Hissar farm has been 500 ewes, 15 rams, and about 300 weaned lambs. During this time only one or two deaths have been attributed to this parasite. The worm, however, can generally be found if searched for at post-mortem examination.

As regards internal parasites, any besides the above two are not of any economic importance in the dry parts of the Punjab.

The alimentary canals of sheep are, however, fine fields for the parasitologist in the wet and riverine tracts. Colonels Walker and Baldrey writing in the now defunct "Journal of Tropical Veterinary Science" both mention several parasites found by them while investigating a disease locally known as "Gillar." This disease appears to be a veritable scourge. Ninety per cent. of sheep in affected areas are said to become infected, and 90 per cent. of animals attacked die. Neither of the above investigators came to

any definite conclusions as to which parasite was the cause of the disease, but both mention the finding of *Hæmonchus contortus* which is capable of causing most of the symptoms described.

Fluke is a source of heavy losses in the Himalayas and foothills. No case has hitherto occurred in Hissar, but the question whether there is any danger of this disease being spread by the agency of canals is worth inquiring into.

External parasites. The only one that has given much trouble at Hissar is the scab parasite. The one or two outbreaks which occurred were, however, speedily stamped out by the usual dipping methods.

There seems to be some difference of opinion as to the prevalence of scab in India. In addition to the outbreaks at Hissar, the writer has several times seen scabby sheep in the neighbourhood. Mr. Cattell, when Superintendent, Civil Veterinary Department, Baluchistan, reported that it was very prevalent there.

Dr. Mollison, first Inspector-General of Agriculture in India, who was much interested in live stock generally, and wrote a volume on stock breeding for his Text-book of Indian Agriculture, however, writes as if he thought the disease was non-existent in the Bombay Presidency, and considering how largely sheep scab looms in the veterinary and agricultural literature of most other countries, it certainly seems to have received very little attention in this. It is hoped that discussion in this conference may add to our knowledge as regards its prevalence. Possibly the fact that Indian sheep are usually shorn twice, and sometimes three times, annually may play some part in checking the spread of the disease. Any way as we know that the disease does exist in India and realize the losses of and preventive measures adopted by other countries, it would probably pay India to adopt similar measures. But the Veterinary Department and the Police are not in the present state of their organization capable of supervising and enforcing such regulations as are enforced in other countries.

Larvæ of *Œstrus ovis* are common in sheep all over the country. Irritation due to them may cause loss of condition, but they are not of much economic importance.

Blow fly maggots in wet seasons are a source of very serious loss. Even at Hissar, when we get any rain in the monsoon period, sheep require a good deal of attention if they are to be kept free from maggots.

Microbic diseases. So far as the Hissar farm is concerned, pneumonia has caused far more deaths than any other disease. Pneumonia is a veritable scourge of young lambs in the cold weather, and generally seems connected in some way with malnutrition. For example, in young lambs, deaths are practically confined to the months of January and February. In these months grazing is generally scanty and the time for grazing is short, and ewes have very little milk. The lambs die at about 3 weeks old. Deaths cease abruptly in March, when the days get longer and grazing on canal banks, etc., improves. In older animals also outbreaks of pneumonia have always been seen at times when grazing was short, and the sheep in poor condition. Changing to better pasture or stall-feeding have proved the best method of treatment. I should like to note in passing that change of grazing and also changing the folds, if the sheep are folded or taken in at night, is generally worth trying if one is called to deal with any obscure outbreak in sheep.

As regards young lambs dying in January and February, a simple way to deal with the problem is to arrange to have no births in the cold weather. Since the Indian custom of running rams with ewes all the year round was given up, losses in young lambs at the Hissar farm have been reduced to practically nil. Soon after the writer joined the farm, out of 90 lambs born in December, January and February, 71 died of pneumonia.

Anthrax is also the cause of a good deal of mortality in sheep. The bad reputation of East Indian wool at home tends to support this theory. Personally the writer has not had much experience of anthrax in sheep, as the Hissar farm was entirely free from this disease from the date the Civil Veterinary Department took it over in 1899 till 1920. In the cold weather of 1920-21 an outbreak of this disease in cattle was accompanied by a few deaths in sheep. One might suppose that under certain circumstances very serious

casualties must sometimes occur. A full discussion on this subject has, however, been provided for under another head in our agenda.

Foot-and-mouth disease is very common in sheep in the Punjab, but as a rule seems even milder in indigenous sheep than cattle. It is, however, a very serious disease in sheep imported from countries free from the disease. Pure merinos suffer very severely, and several have died from this disease at Hissar. Mouth lesions were the most severe, with the tongues often so much swollen that they could not be retained in the animals' mouths.

Although a case of *sheep pox* has not come under the writer's notice, it is a common disease in India. Imported merinos in an outbreak at Hissar, before I joined the farm, suffered severely.

Foot rot is another disease from which losses are serious in some parts of India.

Rinderpest. Several outbreaks of rinderpest in sheep have been recorded in India, but the writer has never seen a case and personally believes that Indian sheep are highly immune. While he was at Muktesar, Holmes failed to infect two sheep experimentally. There were outbreaks on the Hissar farm in cattle in 1914, 1917, 1918 and 1920. The 1917 outbreak was particularly severe and the infection was present on the farm for 9 months; by that time nearly all the sheep in the farm were half or three-quarter bred merinos. One flock was running with and grazing with affected cattle, but no sheep was ever attacked. Most reported outbreaks in India are probably cases of wrong diagnosis by the Veterinary Assistants and are generally parasitic infections in reality.

The writer does not pretend to have mentioned all the diseases of sheep in India, or even in the Punjab. He claims to have mentioned some of the most important, and that losses due to them must cost this country many lakhs of rupees. He thinks it very striking in reviewing this list which was made without any view to that end, how peculiarly suitable the conditions are for veterinary medical intervention. Wire worm, for example, is one of the few internal parasites we can reach with drugs. Over 5 million doses of their wire worm remedy were issued in 1921 by the Union of

South Africa Veterinary Department. Losses from many other parasitic affections could be diminished if more advice from our department were available and we could find listeners. I do not claim that Indian owners drive their sheep to graze in swamps, just because they like to have them die as some people seem sometimes to assume. In fact, the swamp is often the only place, at least in the Punjab, where there is anything to graze. Propaganda work and advice on such subjects are, however, very urgently necessary.

Losses from external parasites are likewise amenable to treatment, although it is doubtful if much can really be done to check scab without compulsory dipping.

We are, however, discussing legislation in connection with the control of disease under a separate head in our agenda. Personally, the writer does not think legislation is of much use unless it can be given effect to, and doubts if the average Veterinary Assistant could be trusted to supervise dipping. He once had it severely impressed on himself that a picked Veterinary Inspector from another province could not be so entrusted.

The same remarks apply in a lesser degree to other diseases. Losses from pneumonia in famine times will always be heavy in areas subject to fodder famine, but it is certain that a great saving would result, if ewes were not bred to lamb in the cold weather.

There is a crying need for more Veterinary Education, both of the general public and the Indian graduate, in such economic problems. We want men who are not only capable of dipping a scabby sheep but can also effectively preach the futility of dipping one sheep in a flock or one flock in an area.

PLATE X.

COIMBATORE SUGARCANE SEEDLING 232 AT BIROWLIE.

MILL TRIALS OF COIMBATORE SUGARCANE SEEDLINGS 232 AND 233.

BY

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In a previous article entitled "Mill Trials of Selected Coimbatore Seedlings" published in this Journal (Vol. XVIII, Part III), the present writer has fully described the nature of the testing work on cane being done and the method of cane growing followed at Pusa and the importance of the factory tests which are arranged for, with a view to obtain reliable data for the guidance both of the sugar industry and the cane growers. It is, therefore, not proposed to repeat the details given there. Suffice it to say that by the method of short planting successfully adopted at Pusa, two new varieties, Co 232 and Co 233, were rapidly multiplied, and three acres under the former and one acre under the latter were put down in February 1923. The crop was grown in a rather sandy field at Birowlie (Plate X) about two miles away from Pusa, which was rented for the purpose. As usual, the cane was planted in February according to the Pusa method described in the article already referred to and was cut on the 18th December. Half a ton of castor cake per acre was given at the time of planting and a dressing of another half ton given at the break of the rains. The canes were grown without irrigation but they stood the hot weather remarkably well. Unfortunately the rainfall of 1923 was most disappointing in this part of North Bihar, only 26 inches of rain being registered against an average of 45 inches. Even then while the local cane *Bhurli* suffered badly, these canes gave a fair yield. While these canes grew well, the deficiency in rainfall was extremely marked when it came to the actual tonnage weight. The canes grew to a good height but failed to swell to the normal extent in an

average year, and it is perfectly evident that, however well a cane may withstand drought, actual tonnage is linked to the rainfall. In North Bihar, cane is grown without irrigation and any great deficiency in the rainfall, such as occurred this year, is bound to be shown in the yield, however strong the cane may be. Three hundred and sixty maunds * stripped cane per acre was obtained in the case of Co 232, while Co 233 yielded only 220 maunds. The whole crop was practically free from any insect pest or fungus disease. It was evident that Co 233 is not able to withstand such conditions, and further tests on this cane will be discontinued.

Both Co 232 and Co 233 are seedlings of the same parents—P. O. J. 213 and Katha (a Punjab cane)— but they vary in a number of characters. Co 232 is a straight growing and early ripening cane with fair vigour and good habit, but it has not been found to tiller so well as Co 213 or Co 210. It is too early yet to pronounce definitely regarding this cane owing to the abnormality of the season in this part of Bihar. As it is highly important to have an early cane to replace Co 214 if the latter shows signs of deterioration or tends to emphasize its present twisted habit in the cultivators' fields, the writer has again put down three acres of this cane in 1924 with a view to find out whether, in point of tonnage, it comes up to the standard of Co 214, i.e., to at least 20 tons per acre. Co 232 is an early cane of erect growth and if it proves a good tonnage cane in a normal season, it can be used to supersede Co 214, but at present no definite decision can be arrived at on this point. It is necessary to emphasize that the great desideratum of the white sugar tract in India is an early cane with a fair tonnage. Growers will not take up a cane, however early, which is much inferior to Co 213 or Co 210 in tonnage, and factories do not want a cane the juice of which shows low purity.

To return to the mill trials. As mentioned above, both these canes are early ripening, and the short rainfall undoubtedly hastened their maturity. It was, however, unfortunately not possible to arrange for a mill trial till the 19th of December when they were

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* 1 maund = 82·28 lb.

put through the Champaran Sugar Factory at Barrah—such delay always militates against a really early ripening cane—and by the time they were crushed both canes were over-ripe. The following are the results of the mill trial :—

I

	Cane mds.	Sugar per cent. on cane	Fibre per cent. on cane
Co 232 ..	932	12·65	15·55
Co 233 ..	148	10·35	17·13

II

Analysis of first juice.

	Brix	Purity
Co 232	21·00	77·61
Co 233	20·00	69·50

III

Analysis of mixed juice.

	Cane mds.	Brix	Sugar	Purity
Co 232 ..	716	19·20	14·20	73·95
Co 233 ..	121	16·00	10·49	65·56

It will be seen that Co 232 is better in the mill than Co 233, but even Co 232 does not in these results show itself to be very desirable from the factory point of view ; while the Brix of the first juice was 21, the purity was only 77, and the percentage of fibre, 15·5, is higher than the mills like.

To sum up. The result of this year's experiment has been to prove that in Co 232 we have a fairly tall, straight growing cane with the character of early ripening and a good sucrose content.

It now remains to find out whether in a normal season it will yield about 600 maunds of stripped cane per acre, and whether healthy well-grown cane of this variety when subjected to a mill trial when fully mature shows better purity. It has already been mentioned above that much of the cane supplied to the factory was over-ripe, and hence the analytical results require further confirmation by comparison with the results obtained with a crop grown under normal conditions of rainfall and crushed at the right time. It is proposed to have such a test carried out in November next along with further tests of other canes.

In conclusion, the writer wishes to express his obligations to Messrs. Begg, Sutherland & Co., Cawnpore, not only for financing this experiment but also for allowing the mill trial to be carried out at their factory, and to Mr. Noel Deerr, Sugar Technologist, for valuable assistance rendered in connection with these mill trials.

NOTES ON MAINTENANCE RATIONS.*

BY

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In 1914, Murray[1] published an account of a method by which the maintenance rations for oxen of varying weights might be accurately ascertained. The following notes are to a large extent based on his work.

A feeding standard is formulated when the amount of food that an animal of 1,000 lb. body weight requires for specific purpose, irrespective of its actual size, is reduced to terms of digestible nutrients. In the same way we can express a feeding standard by stating that an animal of like weight and for an identical purpose requires that quantity of food which will yield a given amount of available energy. Both are the same feeding standard expressed in different terms. The common method of stating feeding standards is per 1,000 lb. body weight, and it is likely to be inferred from this that the requirements of animals of increasing and decreasing weights can be calculated by the rule of three; that such is not the case will be proved later.

That the food requirements of animals are not proportional to their mass has long been an established fact, and the historical notes given by Lusk[2] and others are not without interest.

Sarrus and Rameaux (1839) stated that since the loss of heat in animals must be proportional to their surface area, therefore the heat production must be proportional to the same unit.

Bergmann (1843) suggested that the food requirements of animals are not proportional to their mass, but he gave no experimental data to support his statement.

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* Paper read at the joint meeting of the Sections of Agriculture and Botany, Indian Science Congress, Lucknow, 1923. A summary of this paper has been included in *Pusa Agri. Res. Inst. Bull.* 150.

[1] *Chem. of Cattle Feeding and Dairying.*

[2] *Jour. Amer. Med. Asso.*, **77**, p. 250, 1921.

Regnault and Reiset (1849) wrote :—" The consumption of oxygen absorbed varies greatly in different animals per unit of body weight. It is ten times greater in sparrows than in chickens. Since the different species have the same body temperature and the smaller ones present a relatively larger area to environmental air, they experience a substantial cooling effect, and it becomes necessary that the sources of heat production operate more energetically and that respiration increases."

Bidder and Schmidt (1852) made the following statement which is thoroughly modern in its conception : " The extent of the respiration, like every other component of the metabolism process, is to be regarded as a function of one variable, the food taken, and one constant, a distinctly typical metabolism (Respirationsgrösse) which varies with the age and sex of the individual. This factor characterizes every animal of a given race, size, age and sex. It is just as constant and characteristic as the anatomic structure and corresponding mechanical arrangements of the body. It is in the main determined by the heat consumption in the organism : that is to say, the replacement quota for the heat lost to the body through radiation and conduction to the environment in a given unit of time. It may, therefore, be used to determine this, or in case the factor of heat loss is known, one can deduce the extent of the metabolism. This typical metabolism...... is that of the fasting animal. It must be nearly the same in animals having the same body volume, surface and temperature : the larger the body surface, the body volume and temperature remain constant, or the higher the body temperature, with surface and volume constant, the higher will be the metabolism as determined by the laws of static heat. Of course a sharp mathematical treatment of the phenomenon can be thought of only after very numerous and experimental determinations on animals of most varied form, size and temperature."

Bergmann (1853) again suggested that the food requirements of animals were not proportional to their mass.

Müntz (1873) reopened the question, but it was not until six years later that any definite progressive movement took place.

Meeh published in 1879 a formula for calculating the surface area. This formula assumed that the surface was a function of the $\frac{2}{3}$rd power of the volume. Since animals contain the same materials, weight may be substituted for volume. The result thus obtained was multiplied by a constant K which expressed the relationship of weight in kilograms to surface area in square meters for a given species.

Rübner was the first investigator to apply exact calculation to this problem. In 1883, he gave the results of his detailed quantitative study and announced that dogs varying in weight from 3 to 30 kilograms produced the same number of calories per square meter of body surface, though per kilogram of body substance the heat production was 88 calories in the smallest dog and only 36 calories in the largest one. He remarks :—"Large and small dogs do not metabolise different quantities of food because their cells are differently organized, but because the cooling influences on the skin excite the cells to activity." Rübner at a later date realized that the level of basal metabolism could not be caused by the influence of cooling on the body. As the result of his experimental work Rübner formulated a law governing the relationship between mass and surface area; he established definitely that when the mass is increased 9·75 times, the surface area of the body is only increased 4·43 times; therefore, we find that animals of tenfold mass have only about 4·7 times the body surface.

Richet (1885) almost simultaneously made a like discovery, which fully confirmed Rübner's work. He showed that a cat, a rabbit and a goose, all of similar weights, produced approximately the same amount of heat. He stated that in future one should express all calorimetric observations in terms of surface area and not in weight.

Sondén and Tigerstedt (1895) pointed out that the heat production in children during the period of adolescence was relatively higher per square meter of surface area than in the adult.

E. Voit (1901) published the results of his studies on the application of Rübner's law to other species than dogs. His experiments were carried out on man, rabbits, swine, geese and hens, and he

found that the law was approximately true for all these species. About the same time Oppenheimer showed that the law also holds good for infants.

Dreyer, Ray and Walker (1912-13) found that the surface area, blood volume and cross sections of the aorta and trachea are all proportional to the $\frac{2}{3}$ power of the weight.

Carl Voit's conclusion that the mass of the cells and their power to oxidize materials determines the height of the metabolism was confirmed by Moulton[1] (1916). This worker found that the surface area was a two-third power function of the total body nitrogen of beef cattle and therefore of the protoplasmic mass.

The principle embodied in Rübner's law, which is that the basal metabolism is a simple function of the body surface, has been disputed by Benedict[2] and Dreyer[3], and, as Boothby and Sandiford[4] have recently pointed out, such objections in a strict sense are quite valid. Nevertheless, as Means and Woodwell[5] state, in a broader sense Rübner's law has never been disproved, and while it may be true that the basal metabolism is not strictly proportional to nor perhaps determined by the surface area, the fact remains that it is more nearly proportional to this area than to any one factor so far discovered.

A large animal, for example, one of 1,000 lb. body weight, has relatively a smaller extent of body surface exposed than an animal of 100 lb., and consequently the loss of heat per unit of mass is greater in the smaller animal. The following illustration may help to make this point clear : a cubic foot of water weighs 62·3 lb. and has a surface area of 6 square feet : while a cube of water 2 feet on the side would weigh 500 lb. and has a surface area 24 square feet only, i.e., while the area has increased only 4 times, the mass has increased slightly over eight times.

The amount of heat actually radiated from the skin is considerable but at the same time variable. In warm weather an animal

[1] *Jour. Bio. Chem.*, **24**, p. 299, 1916.

[2] *Boston Med. and Surg. Jour.*, **182**, p. 243, 1915.

[3] *Lancet*, 1920, p. 289.

[4] *Basal Metabolic Rate Determination*, 1920.

[5] *Arch. Int. Med.*, **27**, p. 608, 1921.

loses less heat than in cold weather. Among the factors causing loss of heat other than variations in the atmospheric temperature are exposure to cold winds, rain and snow and the effects from clipping the coats of animals, etc. Exposure to any of the conditions such as are detailed above bring about a loss of heat in the attempt to maintain the body temperature, and if this is to be satisfactorily accomplished more food will have to be consumed. If the food supplied is inadequate for this purpose then the body tissues are oxidized to make good the insufficiency of the food, the result being made manifest by loss of weight and condition. At the same time it must be remembered that while warmth and shelter lead to a saving of food, too high a temperature which may eventually lead to a loss of appetite is not advisable.

By the term maintenance ration one implies the food requirements of an animal sufficient for its maintenance in a state of so called rest, i.e., in a state of tissue equilibrium, where it achieves no gain in body mass, nor performs work on its environment. It is obvious that this state is merely one of apparent rest for certain systems of tissues; for example, the heart must perform actual work unremittingly while the animal organism survives. It is most important to keep this conception in mind, for the requirements of the animal in a state of maintenance are wholly different, both in quantity and character, from those necessary for various classes of production. In a ration supplied solely for maintenance purposes, the essential requirements are of the following order :—

(1) "Fuel" to maintain a constant level of body temperature, and provide the energy required by the systems which function unremittingly for the performance of their work.

(2) "Repair material" in the form of nitrogenous "organic" material to replace the worn out tissue substance, and "inorganic" salts to replace the small but continuously excreted quantities of these necessary products in animal metabolism.

With regard to the second of these desiderata it has been calculated that 0·5 lb. of digestible protein is a sufficient amount

of nitrogenous organic material to provide in the maintenance ration of an ox of 1,000 lb. body weight. However, it has been pointed out by numerous workers that it is not advisable to feed protein at the minimum experimentally estimated rate. McCollum and Simmonds[1] state that certain phenomena observed by them in the course of feeding experiments, when animals were given quantities of food essentials estimated to be adequate but only slightly above the minimum requirements in protein, could be attributed to a considerable lowering of the animal vitality. Although the following observations refer to productive ration, it may be recalled that Haecker showed that the resistance diminishes if an animal is kept for long periods on a low protein intake. Reid Hunt also showed that restriction of diet played a most important part in the variation in resistance offered by animals to certain toxic substances. Munk was also of the opinion that a restricted protein intake definitely diminished the powers of resistance of animals. In the course of an interesting paper on the relation of the necessary intake for growth and maintenance, Aron cites a paper of Waters in which he showed that if a restricted diet were given to calves although limited growth took place the flesh remained "veal" whilst that of the control animals of the same age became "beef." Briefly, it can be stated that, while it is possible to maintain animals in a satisfactory state of health for relatively short periods, it has not yet been satisfactorily proved that by these means their condition can be maintained for extended periods.

The potential energy of a feeding stuff is measured by the amount of heat developed by oxidization. The usual methods of expressing this are as small calories (*c*), kilo calories (C), or therms (T). In the method described by Murray the kilo-pound unit is used (kt.), and it is that amount of heat which is required to raise the temperature of 1,000 lb. of water one degree centigrade.

The total fuel value of a foodstuff which is obtained by burning the substance in a calorimeter does not indicate the true nutrient

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[1] *Jour. Bio. Chem.*, **32**, p. 347, 1917.

value of the material under investigation. A certain amount of the foodstuff when fed to the animals always remains unoxidized, while other portions are only partially oxidized. The unoxidized and partially oxidized fractions of a foodstuff which are excreted in the fæces and the urine have to be deducted from the total fuel value obtained in the calorimeter when estimating the available or metabolisable energy of a given sample of food.

Murray gives the following factors for calculating the available or metabolisable energy or static value of the different feeding stuffs :—

Pure digestible nutrients	*Factors*
Protein	4·93
Fat of oilcakes	9·40
Fat of cereals and pulses	9·00
Fat of hay and straw	8·50
Starch and cellulose	3·76

The maintenance ration for an ox weighing 1,000 lb. is based by Murray on Wolff's standard which allows :—

	lb.
Digestible crude protein	0·75
Digestible crude fat	0·15
Digestible nitrogen-free extract and digestible crude fibre ..	8·00

The above reduced to terms of available energy contains 35·04 kt.; a reduction of 0·01 lb. of the digestible nitrogen-free extract and digestible crude fibre gives an energy value of 35·00 kt.; this figure will be used for calculating the requirements of oxen of varying weights :—

Digestible crude protein	$0{\cdot}75 \times 4{\cdot}93 = 3{\cdot}69$
Digestible crude fat	$0{\cdot}15 \times 8{\cdot}50 = 1{\cdot}27$
Digestible nitrogen-free extract and digestible crude fibre	$7{\cdot}99 \times 3{\cdot}76 = 30{\cdot}04$
	35·00 kt.

(The reason for using the factor 8·50 for the fat is due to the fact that the maintenance portion of most rations is made up of roughages.)

If the food requirements of animals of varying weights were in strict proportion to their live weight, and it be taken that an animal of 1,000 lb. live weight requires 35·00 kt. for maintenance purposes only, then an animal of 1 lb. would require ($35 \div 1{,}000$) and for one

of x pounds the formula would be $x\,(35 \div 1{,}000)$. We have seen however, from the studies of Rübner and E. Voit that the food requirements of animals of varying weights are not proportional to their weight; therefore, the simple formula given above must be discarded.

It has been proved that animals of tenfold mass have approximately about five times the radiating surface; this, taken together with other facts of a similar kind, would indicate that their food requirements will bear a like relationship. The simple formula given above must therefore be amended to: when the body weight x is less than 1,000 lb. something must be added to the proportional amount and when greater something must be deducted. Another way of expressing the above conclusion is to state that when the mass is increased tenfold the food should be increased only five times and vice versa.

Working with the above data Murray deduced the following formula by which it is possible to calculate the maintenance requirements of oxen of any given weight:—

$$\log E = 0{\cdot}7 \log M - 0{\cdot}556$$

E is the amount of available energy (kt.) of the food required and M is the live weight of the animal in pounds.

The above standard given by Murray has been objected to by many authorities on the ground that it is higher than is absolutely necessary. Most of the present-day standards are based on what is known as the "Modified Wolff-Lehmann Standard" which gives the requirements of an ox of 1,000 lb. live weight as:—

	lb.
Total dry matter	17·0
Digestible crude protein	0·7
Digestible crude fat	0·1
Digestible nitrogen-free extract and digestible crude fibre	7·0

The available energy value (kt.) of the above ration using Murray's factors being 30·62 kt., the formula for calculating the requirements of animals of varying weights is as follows:—

$$\log E = 0{\cdot}7 \log M - 0{\cdot}6139$$

Larson and Putney give a table showing the food requirements of animals varying in body weight from 800 lb. to 1,600 lb. according to Haecker whose standard follows the line of strict proportion as regards the digestible crude protein, and the digestible nitrogen-free extract and digestible crude fibre. This according to either of the other standards gives too low a ration for animals under 1,000 lb. body weight and too great an allowance for animals weighing over 1,000 lb. when compared with the "Modified Wolff-Lehmann Standard."

Table I has been prepared to show the available energy requirements of animals of varying weights according to "Murray's Standard," the "Modified Wolff-Lehmann's Standard" and "Haecker's Standard." The formulæ used being:—

Wolff's Standard	$\log E = 0{\cdot}7 \log M - 0{\cdot}5558$
Modified Wolff-Lehmann's Standard	$\log E = 0{\cdot}7 \log M - 0{\cdot}6139$

Haecker's rations have been calculated by the aid of Murray's factors.

The following additional formulæ have been worked out by which it is possible to calculate the quantity of total dry matter and of the different digestible nutrients required by animals of various weights according to either Murray's or the Modified Wolff-Lehmann's Standard.

Requirements.	*Wolff's Standard.*
Total dry matter	$\log A = 0{\cdot}7 \log M - 0{\cdot}8569$
Digestible crude protein ..	$\log B = 0{\cdot}7 \log M - 2{\cdot}2249$
Digestible crude fat	$\log C = 0{\cdot}7 \log M - 2{\cdot}9238$
Digestible nitrogen-free extract Digestible crude fibre ..	$\log D = 0{\cdot}7 \log M - 1{\cdot}1974$

Requirements.	*Modified Wolff-Lehmann's Standard.*
Total dry matter	$\log A = 0{\cdot}7 \log M - 0{\cdot}8696$
Digestible crude protein ..	$\log B = 0{\cdot}7 \log M - 2{\cdot}2549$
Digestible crude fat	$\log C = 0{\cdot}7 \log M - 3{\cdot}1000$
Digestible nitrogen-free extract Digestible crude fibre ..	$\log D = 0{\cdot}7 \log M - 1{\cdot}2549$

The simple formulæ given below are for those who are not familiar with logarithms. They provide a ready means for estimating the requirements of animals of varying weights provided the

available energy or kt. requirements are known for the weight of the animals to be fed.

Requirements		*Wolff's.*	*Modified Wolff-Lehmann's*
Total dry matter ..	..	= E ÷ 2	E ÷ 1·8
Digestible crude protein	..	= E ÷ 46·7	E ÷ 43·74
Digestible crude fat ..	..	= E ÷ 233·4	E ÷ 306·2
Digestible nitrogen-free extract Digestible crude fibre ..	.. ..	= E ÷ 4·3805	E ÷ 4·374

Table II shows the requirements of animals for maintenance purposes only of total dry matter and the different digestible nutrients. The figures given under Murray and Modified Wolff-Lehmann have been calculated by the logarithm formulæ given above, those under Haecker are as given by Larson and Putney.

The formulæ given throughout these notes have been based on data obtained from experiments carried out on European and American cattle. How far the figures so obtained can be successfully applied to Indian cattle-feeding problems can only be satisfactorily settled after a considerable number of prolonged feeding experiments have been carried out.

It may be found that while the Modified Wolff-Lehmann Standard will answer for oxen, Murray's Standard will have to be closely followed for buffaloes. The tables given in this paper have been compiled with the hope that they may prove of some service to workers on nutrition problems in India.

It is necessary to bear in mind that all feeding standards are simply averages and approximations. The tables given are for guidance only ; to use them as infallible prescriptions not to be varied under any circumstances whatsoever is to invite disaster. While a ration may be chemically correct, it may be practically wrong. In such cases it is necessary to study the idiosyncrasy of the animal concerned, to endeavour to trace the factor or factors that are acting in such a manner that the animal in question is proving an exception to the general rule and not to condemn blindly the chemists' work.

According to Murray, the formula given for oxen is also correct for horses so that the available energy figures given in Table I can be used for this species also. Linton, however, has objected to Murray's maintenance rations for horses on the ground that they

are excessively high. Further it should be noted that the formula $\log E = 0 \cdot 7 \log M - 0 \cdot 556$ does not apply to sheep, the maintenance ration formula for this class of animal being $\log E = 0 \cdot 7 \log M - 0 \cdot 8$. If the maintenance rations for sheep were to be calculated by the oxen formula, an animal weighing 100 lb. would require that quantity of food which would yield 6·93 kt. of available energy, whereas it is known that an animal of this weight requires considerably less, the amount being 4 to 4·5 kt. according to the texture of the wool.

TABLE I.

Body weight	Available energy requirements		
	Wolff's Standard	Modified Wolff-Lehmann Standard	Haecker Standard
lb.	kt.	kt.	kt.
100 ..	6·93	6·06	....
150 ..	9·21	8·09	....
200 ..	11·34	9·92	....
250 ..	13·26	11·60	....
300 ..	15·07	13·18	....
350 ..	16·79	14·69	....
400 ..	18·43	16·16	....
450 ..	20·02	17·51	....
500 ..	21·54	18·86	....
550 ..	23·03	20·15	....
600 ..	24·48	21·42	....
650 ..	25·89	22·67	....
700 ..	27·27	23·85	....
750 ..	28·63	25·03	....
800 ..	29·94	26·19	24·49
850 ..	31·24	27·33	25·98
900 ..	32·52	28·44	27·55
950 ..	33·77	29·54	29·04
1,000 ..	35·00	30·62	30·62
1,050 ..	36·22	31·66	32·10
1,100 ..	37·42	32·73	33·68
1,150 ..	38·60	33·77	35·09
1,200 ..	39·77	34·97	36·74
1,250 ..	40·93	35·80	38·13
1,300 ..	42·08	36·80	39·80
1,350 ..	43·19	37·79	41·29
1,400 ..	44·30	38·76	42·85
1,450 ..	45·40	39·72	44·40
1,500 ..	46·49	40·67	45·93
1,550 ..	47·57	41·62	47·42
1,600 ..	48·64	42·55	48·99
1,650 ..	49·71	43·48	....
1,700 ..	50·75	44·39	....
1,750 ..	51·80	45·31	....
1,800 ..	52·93	46·22	....
1,850 ..	53·86	47·11	....
1,900 ..	54·78	47·99	....
1,950 ..	55·88	48·78	....
2,000 ..	56·87	49·75	....

Table II.

Body weight lb.	Total dry matter lb.	Digestible nutrients: Crude protein lb.	Digestible nutrients: Crude fat lb.	Digestible nutrients: Nitrogen-free extract and crude fibre lb.
	A	B	C	D
WOLFF'S				
100	3·4	0·148	0·029	1·58
150	4·6	0·197	0·039	2·10
200	5·6	0·243	0·048	2·59
250	6·6	0·284	0·056	3·02
300	7·5	0·322	0·064	3·43
350	8·3	0·359	0·071	3·83
400	9·2	0·395	0·078	4·20
450	10·0	0·428	0·085	4·56
500	10·7	0·461	0·092	4·92
550	11·5	0·493	0·098	5·25
600	12·2	0·524	0·106	5·58
650	12·9	0·555	0·110	5·91
700	13·6	0·584	0·116	6·22
750	14·3	0·616	0·122	6·53
800	14·9	0·641	0·128	6·83
850	15·6	0·669	0·133	7·12
900	16·2	0·696	0·139	7·42
950	16·8	0·723	0·144	7·70
1,000	17·5	0·750	0·150	7·99
1,050	18·1	0·776	0·155	8·26
1,100	18·7	0·801	0·160	8·54
1,150	19·3	0·827	0·165	8·81
1,200	19·8	0·852	0·170	9·08
1,250	20·4	0·877	0·175	9·34
1,300	21·0	0·901	0·180	9·60
1,350	21·5	0·925	0·185	9·88
1,400	22·1	0·949	0·189	10·11
1,450	22·7	0·972	0·194	10·36
1,500	23·2	0 996	0·199	10·61
1,550	23·7	0·020	0·203	10·86
1,600	24·3	1·042	0·208	11·10
1,650	24·8	1·065	0·212	11·34
1,700	25·3	1·087	0·217	11·58
1,750	25·8	1·110	0·221	11·82
1,800	26·4	1·132	0·226	12·06
1,850	26·9	1·154	0·230	12·29
1,900	27·4	1·176	0·235	12·52
1,950	27·9	1·198	0·239	12·76
2,000	28·4	1·218	0·243	12·98
MODIFIED WOLFF-LEHMANN'S				
100	3·3	0·138	0·019	1·38
150	4·5	0·184	0·026	1·84
200	5·5	0·227	0·032	2·27
250	6·4	0·265	0·037	2·65
300	7·3	0·300	0·043	3·00
350	8·1	0·325	0·047	3·25
400	8·9	0·368	0·052	3·68
450 ..	9·7	0·400	0·057	4·00

TABLE II.—*concld.*

MODIFIED WOLFF-LEHMANN'S

Body weight lb.	Total dry matter lb.	Digestible nutrients: Crude protein lb.	Crude fat lb.	Nitrogen-free extract and crude fibre lb.
	A	B	C	D
500	10·4	0·431	0·061	4·31
550	11·1	0·460	0·065	4·60
600	11·8	0·489	0·069	4·89
650	12·5	0·518	0·074	5·18
700	13·2	0·545	0·077	5·45
750	13·9	0·572	0·081	5·72
800	14·5	0·598	0·085	5·98
850	15·1	0·624	0·089	6·24
900	15·7	0·650	0·092	6·50
950	16·4	0·675	0·096	6·75
1,000	17·0	0·700	0·100	7·00
1,050	17·5	0·724	0·103	7·24
1,100	18·1	0·748	0·106	7·48
1,150	18·7	0·772	0·110	7·72
1,200	19·3	0·805	0·113	8·05
1,250	19·8	0·818	0·116	8·18
1,300	20·4	0·841	0·119	8·41
1,350	20·9	0·861	0·123	8·61
1,400	21·5	0·885	0·126	8·85
1,450	22·0	0·908	0·129	9·08
1,500	22·5	0·929	0·132	9·29
1,550	23·1	0·951	0·135	9·51
1,600	23·6	0·972	0·138	9·72
1,650	24·1	0·994	0·141	9·94
1,700	24·7	1·014	0·144	10·14
1,750	25·1	1·036	0·147	10·36
1,800	25·6	1·056	0·150	10·56
1,850	26·1	1·076	0·153	10·76
1,900	26·6	1·104	0·156	11·04
1,950	27·1	1·118	0·159	11·18
2,000	27·6	1·137	0·162	11·37

HAECKER'S

800	....	0·560	0·08	5·60
850	....	0·595	0·08	5·95
900	....	0·630	0·09	6·30
1,000	....	0·700	0·10	7·00
1,050	....	0·735	0·10	7·35
1,100	....	0·770	0·11	7·70
1,150	....	0·805	0·11	8·05
1,200	....	0·840	0·12	8·40
1,250	....	0·875	0·12	8·75
1,300	....	0·910	0·13	9·10
1,350 .. .	....	0·945	0·13	9·45
1,400	....	0·980	0·14	9·80
1,450	....	1·015	0·14	10·15
1,500	....	1·050	0·15	10·50
1,550	....	1·085	0·15	10·85
1,600	....	1·120	0·16	11·20

THE FRUIT MOTH PROBLEM IN THE NORTHERN CIRCARS.*

BY

P. SUSAINATHAN, F.E.S.,

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For the past three years there have been complaints in the Northern portion of the Madras Presidency from certain taluks of the Kistna District as to a heavy fall of fruits in pomegranates, oranges and sweet limes during the months of July to August. Investigations carried out during 1923 and the previous years show that the fall is due mainly to three species of Noctuid moths (*Ophideres materna*, Linn.; *Ophideres fullonica*, Linn.; and *Anua coronata*, Fabr.) which visit the trees at night and puncture the ripening fruits with their powerful file-like proboscides. They not only suck the juice but also induce a rotting of the pulp as they provide entrance for bacteria which ultimately cause the fruit fall. On actual experiment, it was found that a single moth could drill 15 to 20 holes into a sweet pomegranate in one night. The number of punctures in oranges and mangoes are far less on account of the ready availability of the fruit juices. Sour pomegranates and sour limes are not affected. The pomelo has too thick a rind to be penetrated by the sucking organs of these moths.†

Visits to the affected area were somewhat too late in 1921 to enable one to study the whole problem thoroughly, but during 1922 observations made in August shed a certain amount of light as to the nocturnal habits of the perpetrators of the damage. A trial was made in reference to the possibility of destroying the moths

* Paper read before the Agricultural Section of the Indian Science Congress, Bangalore, 1924.

† Pomelos have been reported to be damaged severely by these moths in the Bombay Presidency (*Proc. Third Entl. Meeting*, p. 86). [T. B. F.]

by attracting them to traps of poisoned molasses, flavoured with fruit essences, such as those of the orange, lime and pine-apple. The pine-apple essence was found to be decidedly in favour with the moths. Several dozens of moths were found feeding on the bait and some of these were caught and caged and found to succumb in 24 to 48 hours, thus establishing the possible efficacy of poison-baiting. Due to the disappearance of the moths during the second week in August 1922, these very interesting sets of experiments had necessarily to be postponed.

The question was again taken up in earnest in June–August 1923. There were several points to be discovered both in regard to the life-cycle of the pests and their attraction to poisoned scented molasses baits in preference to the fruits on the trees. Investigations were started in the village of Mathimuthanagudem lying in a submontane tract, 40 miles from Ellore, Kistna District. In June-July, after considerable effort, the breeding places of many of the major visitants to fruits were discovered and an early campaign was instituted against one of the larval foodplants, *Tinospora cordifolia* (Fam. Menispermaceæ) known as "Tippa-tiga" in Telugu, which breeds the major pest *Ophideres materna.* This is a creeper which grows mostly among thick and neglected hedgerows and among clumps of vegetation in the midst of the cultivated area. The creeper does not affect forest areas. Besides this, *Cocculus hirsutus* (Fam. Menispermaceæ) and *Combretum ovalifolium* (Fam. Combretaceæ) are two more weeds on which *Ophideres fullonica* and *Anua coronata* breed respectively. The campaign against these foodplants was started on the 24th June, and by the 9th July the bulk of the weeds referred to had been cleared from the village precincts. Four to five hundred caterpillars of fruit moths were taken from the creepers and most of them reared out into moths in cages. Since the few moths that in nature survive from probably the previous season's brood begin to breed towards the end of June, a campaign against the larval foodplants at this time may be calculated to ensure the destruction of hundreds of caterpillars which, if allowed to turn into moths, would damage every fruit in the orchard. As a result of endeavours made to find

out the egg-laying capacity of the moths, two females were found to lay a total of 302 eggs spread over 13 days in captivity. Nevertheless, when compared with that of other moths of the same group, this figure does not by any means represent the maximum capacity of the moths in nature.

In 1923, as a result of the campaign, no moths had appeared in the orchards till the end of the first week in August, thus tiding over the period in which a severe loss is sustained year by year. But, due to the indifference of the orchardist who did not attend to a thorough removal of the weeds, a second brood of caterpillars would appear to have developed early in August, leading to the emergence of a large number of moths and consequently to a considerable amount of fruit fall later on. In contrast to this gardener, another orchardist, who had taken pains to remove the fruit-moth-breeding weeds in another orchard some 20 miles off, wrote on 17th September, 1923 :—" I have cleared to some extent the *Tippa-tiga* (*Tinospora cordifolia*) and *Yethala-tiga* (*Combretum ovalifolium*) but it was not possible to destroy them all at once, as they were found to sprout up again, but still in our gardens, we had not much loss on account of the insects. . . . . . I can now definitely say that from the time you came here and advised me on the clearing of the weeds, there had been no loss in my garden due to the ravages of the insects." The foregoing facts show that a *raiyat* who had not cared to understand or to connect the existence of particular weeds with the periodical appearance of fruit moths and thereby had omitted to eradicate them in the vicinity of his orchard suffered a heavy loss, whereas another *raiyat* in a different village, acting under advice, had profited by the removal of the weeds.

Apart from the poison baiting of fruit visiting moths which is yet in an experimental stage, there is thus a direct method whereby the axe may be laid at the root of the whole trouble, namely, the thorough eradication of the foodplants on which these fruit pests breed, illustrating the old, old adage, " Prevention is better than cure."

Selected Articles

THE TEACHING OF AGRICULTURE.*

BY

SIR A. DANIEL HALL, K.C.B., LL.D., F.R.S.,

Chief Scientific Adviser and Director-General of the Intelligence Department of the Ministry of Agriculture.

I CANNOT help feeling that the object of my remarks is still somewhat in a tentative condition, and it may be better if I reserve a formal exposition of the subject so that all I have to say may be regarded by way of stimulus and suggestion rather than a direction to a particular action that I should like to see taken. This must be the case with all good teaching. The teacher has to work out a method, that method may not be a good one for universal adoption, but if a man has worked it out for himself and is keen, the very fact of his keenness may make that method an extremely profitable one.

CLOSER CONSIDERATION OF THE METHOD OF TEACHING.

What I have to bring before you is this, put broadly, that the actual method of our teaching, whether we teach inside the college or the farm institute or whether we teach in the county, requires more consideration than it ordinarily gets. We all of us in this country begin teaching agriculture in a thoroughly haphazard amateurish fashion. We go to college and later on when we leave, we find ourselves put in front of a class and required to teach on our own account. I think most people's experience would be similar to mine; no one gave me a hint or suggestion of what methods to follow—I floundered about and tried one method after another.

* Substance of an address given at the Agricultural Education Association at Aberystwyth

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Many scientific and technical men have a certain scorn for what generally may be called the art of exposition, whether in speech or writing. In writing I have often occasion to deplore the style and quality of the written matter that is put out. In teaching I have from time to time listened to lectures and classroom instruction, and I do think the teaching might be enormously improved if the men thought a little more about this matter of teaching as an art in itself, independent of the material that is to be set forth, an art which has a code of rules and laws of its own. I do not want to lay down methods at this moment. Every man will think out his own method, but I do want to plead for a consideration of the method itself as something worth thinking about, something by which the work—whether it is in classroom or lecture room—can be made more effective. I want you to take it that teaching is not a process into which you drop quite naturally, that it only involves the doling out of so much information to be got up by the class, whereby all the teacher can be expected to do will have been accomplished. If that were the case, if there were nothing in the functions of the teacher but to hand out a certain amount of knowledge, why have any oral teaching at all ? Why not content oneself with books, or with some kind of organization like the correspondence college ? The organization of a correspondence college, for example, can show the student exactly what he ought to read, it can set him papers, mark and comment on them. The way these colleges flourish proves that they can be effective in promoting the acquisition of knowledge for examination purposes. In fact one must take it that the very existence of these correspondence colleges on a large scale points out that there is a defect in the ordinary teaching given in the country. If the oral teaching were of the right kind, the correspondence college, which gets its results and could not live if it did not get its results, would go out of existence.

To give an illustration of what I mean ; you are all familiar with one of the very commonest forms of classroom teaching in University or University College the lecturer who practically dictates to his students a certain text which he has prepared. The lecturer prepares very carefully his lecture as a résumé of a particular

section of the subject and delivers this from the platform so that every student may take it down verbatim and get it accurately transcribed into a notebook. That form of instruction is very popular, especially amongst students. It supplies them with a short cut to knowledge ; it absolves them from the necessity of reading anything other than their notes. They need not buy text-books ; still less need they compare the different views of other people on the subject, and they regard this as a very profitable form of instruction. If they get up the notes which the protessor has given them they expect to be able to pass the required examination. One knows the type of lecture notebook which is produced in that way, and I believe in some of the Universities it has considerable financial value. That always reminds me of a story of a Cambridge undergraduate in the time of a very famous coach known as Big Smith. The undergraduate had just come into residence and was taking counsel with some senior friends as to what course to pursue, should he read for Honours or a Pass. He asked what was the difference between a Tripos and a Poll degree. The old hand replied " if you go for the Tripos you go to Brown, of Trinity, and he tells you what he thinks about it ; then you go to Jones, of Jesus, and he tells you what he thinks about it ; then you go to Tomkinson, of Caius, and he tells you what some other Johnny thinks. If you take a Poll you go to Big Smith and he tells you what it *is*." That is the attitude of the typical undergraduate ; he wants positive knowledge delivered to him in neat little packets ready to be handed over the examination counter. I submit, however, that the teaching of that kind will eventually be replaced by the gramophone. It would be cheaper to the University to replace such professors by gramophones.

Of course there is the converse of the process, where the lecturer refuses to allow his students to take a note at all. That was my own practice in the later days of my actual teaching career. I was asking my students for their attention ; I did not want them to divert their attention by taking notes. The object of my lecture was to impart a point of view and to get my students to apprehend the principles of the subject. So far as notes went, it was my practice

to issue a typescript at the end of the lecture, which contained subject headings, tables and diagrams, and references to the text-books indicating where details of the matters dealt with could be found. I do not say mine was the right way but it was an attempt to teach, whereas the other way is only an attempt to supply information. I throw out that as an illustration; the point I want to make is that the mere process of teaching does require thinking about.

On the other side, let us take the outside lecture, the lecture that every college or institute teacher is required to give from time to time to audiences in villages and country centres. As a rule the preliminaries are organized for him; he walks into the place and is rather apt to suppose that if he delivers the lecture and the people do not leave the room in too large quantities during the process, that his method is good. If the audience falls off during the lecture course, he blames the organization.

But we have to ask ourselves whether the lecture method is suited to the village audiences at all, whether the type of teaching we have to do in the counties has not got to start from an entirely different point of view. I want to suggest that the prime effort of the extra-mural teacher must be in some way to drag the members of the audience into the fray themselves. They must be led to become active participators in the process of education. You have not much time in dealing with an audience of that description; you are running over the whole of agriculture, perhaps in six lectures and you only have time for stimulus. The technique of the process by which you can get your pupils to read and work for themselves does require a good deal of consideration. Put yourself the question, "How am I to get my audiences to help themselves? I, in charge, can only help people, I cannot teach them; I can only point out the lines upon which they can teach themselves."

How we can improve our methods of teaching.

I take these as illustrations of the kind of subject I should like to see discussed, the methods of teaching inside and outside the college, how, by thinking for ourselves, we can improve our own

methods. I want specifically to suggest the question of how the subject of agriculture itself ought to be treated in our colleges and farm institutes, etc., because there I can see perhaps the greatest opening for better technique and indeed for some considerable reconstruction of our aims in teaching agriculture.

I think we are inheritors in this country of rather a mistaken tradition. I know quite well 30 years ago when colleges began to start in Great Britain for the teaching of agriculture, the general idea of their founders was that agriculture could be regarded as an assembly of applied sciences. There was chemistry, botany, zoology, geology and so forth, all sciences throwing light upon the growing of crops and the feeding of animals. If we first taught these sciences to agricultural students and then the application of those sciences to agriculture, we were teaching agriculture. You may remember that the first Cambridge diploma did not proceed further than that. It was content with an examination in applied sciences and treated agriculture itself as one of those rather mechanical extras which are pursued in practical life but which should hardly concern the university. So I think we were given a set towards the treatment of agriculture as just an assembly of applied sciences, and it was conceived that we could bring out a farmer by grounding the youth thoroughly in chemistry, botany, zoology and so forth.

Now agriculture is a subject *sui generis*, something quite distinct from an applied science ; it has its own technique and methods and its own fundamental science, which is neither chemistry, botany nor zoology, nor anything of the kind popularly termed science. It is accountancy which lies at the basis of the teaching of agriculture, and as pure chemistry is the grammar of the agricultural chemist and botany of the agricultural botanist so is accountancy the grammar fundamental in the instruction of the farmer.

The object of our teaching.

If we start off with that somewhat one-sided statement we shall get a little nearer to what is the right form of teaching. Let us begin by asking ourselves what we are after when we are dealing with the young men in an agricultural college. What is our object ;

what are we going to try and turn out ? I think it is agreed that we are not thinking of turning out teachers, officials or that kind of man ; we are thinking really of turning out a thoroughly equipped farmer and we want to ask ourselves what we mean by that—a thoroughly equipped farmer under modern conditions, and how we can help to ensure that type of man by education. We know well the old farmer who has no education behind him ; he tells the teacher that no one can learn farming in a classroom and that he has no opinion whatever of book farmers. The answer is not easy, but I think we can remove that kind of reproach if we take our teaching of agriculture from a somewhat different angle. What he means is that success in farming depends upon a number of qualities which are personal and many of which are only obtained by experience. If a man has no will or determination, if he lacks a certain firmness about making a bargain, of course he cannot become a successful farmer—and none of the efforts of the educator are directed towards giving these qualities.

Still, putting aside these inborn faculties and the essential matter of experience, what does characterize a good farmer as distinct from a bad farmer ? We can sum it up in one word—management. The good farmer not only knows what work has to be done, what good work is, the technique of growing his crops and breeding cattle, etc., but he knows how most effectively to dispose of the staff of labour that he has on that particular land. His job as farmer is a manager. The agricultural college is dealing mainly with men who are going to be managers of labour, directors of other people's work. They are not going to do manual work themselves, except perhaps in their younger days, but in the main they are going to be heads and not hands.

Developing the idea of management.

When you turn to compare the successful with the unsuccessful farmer you will probably find in a great many cases that the question of financial success depends upon this disposal of labour more than anything else. We may sum up the object of the agricultural college as the training of managers. That being the case, what I

want to submit to you is that we must direct our teaching to that end.

Suppose we turn to one of the most successful text-books on agriculture that we have in England, the late Professor Fream's — almost the only widely distributed text-book that has been written in English on agriculture—do you find that point of view, management, set out from the beginning of the book to the end? There may be an odd chapter or two about it, but in the main the book is concerned with the description of the materials of the farmer. You are told how to discriminate between fescues and poas, hop trefoil and yellow clover—just the kind of things that are so much taught and learned by the agricultural student and so heartily despised by the old type of farmer. The old farmer is wrong; you cannot know too much of anything. None of these descriptive points are without their value, only they cannot replace the other things, the vital study of the economics of a farm and its management. That is the point that I want to bring forward in these remarks.

The teaching of agriculture as I have seen it, and I speak from experience, is far too much a mere matter of description. It may not even be descriptive of the kind of farm the teacher knows himself, it may be a discussion on the old systems of farming. It is not unknown that men continue to teach the East of Scotland form of agriculture as described in Stephens' "Book of the Farm" as the only method of successful farming. It may have had little to do with the farming that was going on round about the college, having been worked out on a different rotation and for a different soil and climate. Let us have done with this purely descriptive teaching of agriculture.

The teaching of agriculture should be to an increasing degree a matter of personal experience, and it should be in every district largely based upon what is going on round about the college. It should begin as a description, so far as it is descriptive, of the farming practice amongst the people the student comes from; that is the first thing; let us localize our teaching. In this way the teacher can introduce the element of personal investigation; he

begins by finding out what the people round about are doing, that will lead him to comparisons of their methods with other people's methods. He can fall back on the standard system of his text-book, compare it with the local system and discuss the difference that he finds between the two. The critical faculty is brought into play.

But we must go a step further if we have in view management, so that the student, when he leaves college and begins to work on his own account, shall be in a position to be critical of the work that he gets done, and not merely in the hands of his foreman or bailiff. We must not be content merely with describing. We must ask ourselves about each of the processes, how many men, how many horses, how much time, what will it cost step by step, and criticise these costs in the light of the results. Here the real critical process comes into play. The agricultural teacher dealing with, say, the potato crop, should have acquired for himself, by direct observation, a picture of the practice of a successful potato grower under certain conditions. He has followed the crop through, he has found out the number of men at work and the amount they did, and he is in a position to sum up the costs. That alone is a description which may be a great help to a student later on. But if he can set alongside that a description of the methods of two other equally good farmers and in different districts with the details of the alternative operations, the number of men on the job and the costs, I should think he is entering his students in the art of being managers. That is the first step. It has not got to end there.

After the teacher has been through the raising of crops and the treatment of livestock as individual operations, he has got to get his students into a perception of how a really good farmer schemes out his work from week to week, and how, given a certain staff at his disposal, he uses them to the best advantage. From my own observation of practical farming there lies the difference between the successful and the bad farmer—the way in which a good farmer has his work planned out and with a given staff always is ready to throw in his strength at the right moment. Of course you cannot teach that but you can awaken the student very much to the necessity of thinking it out for himself.

It is in that connection the college farm is going to be most useful for the purpose of the teacher. The college farm should be run as a practical business proposition which is illustrating management and which is a text-book of the teacher in the lessons he is giving. Every student should keep an exact diary week by week of the operations that go on on the college farm, and it should be a diary with full details. It does not record "March 15th, sowing barley on the 10-acre field." No, he says "sowing barley on the 10-acre field ; wheat stubble ploughed in November, wanted more frosts, a little stale on top and wet below." Then should follow the operations, the horses and men to each and the time taken. Further, the teacher should be giving the actual cash transactions from week to week. The teacher taking his class on Monday morning will say "our business during this week is so and so, I propose the men shall do so and so," and he shows them how he has schemed out the use of his staff during the week and the alternative in case the weather is unfavourable. It is in this way we can make our agriculture itself scientific, and not merely descriptive of accessory scientific facts which may be of value but which are of secondary importance compared with the question of management.

When we get on to the second and third year of teaching we have to consider broader economic questions ; the reason for this or that branch of the business, why we are producing milk, why we are fattening bullocks, etc. We can begin with a consideration of the policy of the college farm, for it is the one which is close at hand, the one about which the teacher has the most details. But neighbouring farmers are generally willing to help the college by disclosing enough of their accounts to give the teacher materials for the discussion of policy. Now this means that agricultural teaching should be founded upon a system of cost accounting. The future of efficient management depends fundamentally upon a good book-keeping system to begin with, and the constant use of that book-keeping to check operating costs, so I think that the student must be inducted early into the point of view of cost accounting.

We are apt sometimes to assume that we can describe the right method of farming. I do not think there is a right method of

farming, there is only a best compromise to adopt under given circumstances as regards soil, climate, markets, etc. The teacher's object should be to get the student into a critical way of examining other people's work so that eventually he will pass on to criticise his own work. The machinery for this is only to be supplied by a sound system of costing. Therefore the teacher of agriculture should investigate costs for himself so as to establish a comparative system of teaching, comparing A's methods with B's methods and discussing with his class how relatively they arrive at the same ends though one may cost a little more. He is then in a position to criticise the whole conduct of particular farms, always with the management in view, and the results in cash as the fundamental test of the rightness or otherwise of the operation.

I do not think I need say anything more. I could have elaborated, but I rather want to throw out these suggestions for you to turn over for yourselves and see if they will not strike on your box and modify the methods by which you teach. I am convinced that if you think about these points of the technique of teaching, you can make your work more effective.

KIKUYU GRASS (*PENNISETUM CLANDESTINUM*, CHIOV.).*

BY

O. STAPF.

In 1911, Mr. J. Burtt-Davy received from Mr. David Forbes of Athole, Amsterdam, Transvaal, a single root of peculiar grass which he had collected on the shores of Lake Naivasha, Kikuyu, whilst hunting there, the grass having attracted his attention by the partiality which the wild game showed for it. The root was transplanted in one of the plots of the Botanical Station at Groenkloof, Pretoria, and soon established itself.[1] It has since flowered there regularly every year, but not seeded, the original plant and its descendants being apparently all functionally female.[2] In " The Farmer's Weekly " of March 23rd, 1917, Mr. H. A. Melle published a fuller account of the grass as it presented itself under cultivation, the greater part of which is reproduced here.

" Kikuyu grass (*Pennisetum longistylum*), says Mr. Melle, is a perennial, running grass, and like the ' kweek ' forms a dense turf. It has branching, leafy stems. The leaves are flat and spreading. Kikuyu has numerous stout rhizomes, as thick as a lead-pencil, and by the growth of these a single plant may cover an area of several square yards. If grown in a vicinity where there is not much moisture it will make very little top-growth, but will send out shoots and spread along the ground and establish itself firmly. But in the presence of moisture it will put on top-growth.

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* Reprinted from *Kew Bull.*, 1921, p. 85.

[1] A preliminary note announcing the introduction of the grass was published in the *Report on the Department of Agriculture, Union of South Africa*, 1910-1911, p. 241. Here also appears the name Kikuyu grass for the first time.

[2] A short article by Mr. Burtt-Davy in the *Agricultural Journal of South Africa*, II pp. 146–147, describes the experience gained with this grass in the Transvaal by them (1915), and deals with its uses and disadvantages. It also states the circumstances of its introduction, and that with some reserve it had been referred at Kew to *Pennisetum longistylum*.

I have seen it grow $2\frac{1}{2}$ to 3 ft. high. As yet it has not been observed to set seed in South Africa although it flowers regularly at the Groenkloof Botanical Station every summer.

Kikuyu is a summer grass, but will remain green until the first severe frost and will start growing again long before the veld grasses. At the time of writing our mealies have been scorched by frost and the veld grasses have become coarse and dry ; whereas the Kikuyu is still putting on growth and is beautifully green and succulent. Its drought-resistant qualities have proved to be equal if not better than any of the other grasses.

Kikuyu may be considered as essentially a pasture grass. In districts where the rainfall is over 30 inches it might be possible to get two or three cuttings a season. What number of plants it can carry per acre has not been ascertained, but it will probably carry more than any other grass owing to its dense and rapid growth, combined with its resistance to eradication. If a sod of this grass be taken up, a few rhizomes (underground shoots) are always left in the ground ; these in two weeks' time will send out green leaves and soon re-establish themselves.

As Kikuyu can only be propagated by roots or runners, the initial cost of establishing a pasture would be more than other grasses that bear seed. This, however, is compensated for by the fact that when it has been put in, provided there is sufficient moisture in the soil to start it growing, it will take care of itself. There is, moreover, no fear of it becoming choked by weeds. Although Kikuyu is such a hardy and vigorous grass, it would be advisable to well prepare the ground previous to planting as it will then strike immediately and have an advantage over any undesirable plant.

(*a*) *Palatability.* I can say with every assurance that Kikuyu is one of the most palatable grasses. All stock eat it greedily and will leave most grasses to get to it. If stock are allowed on a patch of Kikuyu it will be seen that they will graze contentedly, and when they have had their fill they like to lie down on it, for the Kikuyu forming such a dense turf provides a very comfortable rest.

(*b*) *Chemical analysis.* From the following table kindly supplied by the Division of Chemistry, it will be seen that Kikuyu is one of our most nutritious grasses :—

Air-dried material	Moisture	Protein	Carbohydrates	Fat (ether extract)	Crude fibre	Ash	Containing true protein	Nitrogen	Albuminoid nitrogen
Kikuyu grass ..	8·29	12·36	35·06	1·70	33·08	9·42	8·31	1·977	1·330
Guinea grass (*Panicum maximum*) ..	8·02	9·03	28·63	1·68	40·54	12·10	7·09	1·445	1·134
Warm baths grass (*Digitaria* sp.) ..	10·94	8·33	25·22	1·72	34·56	9·23	6·13	1·333	0·980
Vinger grass ..	6·93	8·12	33·94	1·68	39·68	9·65	5·51	1·299	0·882
Blauwzaad grass (*Eragrostis* sp.)	7·91	6·58	43·78	1·80	34·50	5·43	5·43	1·053	0·868

Kikuyu grows well on any kind of soil but thrives best on moist vlei soil. We have it growing on alluvial vlei, on heavy clay loam, on gravel clay, on red loam, and poor impoverished stiff clay. On all these it is doing remarkably well. It is also known to do remarkably well on sandy soils.

Like all other grasses Kikuyu has also its disadvantages, and amongst these the chief are :—

(1) It is a summer grass as it does not remain green throughout the winter, unless watered and not subjected to frost.

(2) As it does not appear to form seed in this country, the only means of propagating it is by runners, hence freight, which involves additional expense. And it may happen that when it reaches its destination the ground prepared for it may not have sufficient moisture to start it growing. Although this is enumerated as a disadvantage it may also be considered as an advantage; yielding no seed there is no fear of it establishing itself voluntarily in an adjoining field.

(3) Being such a hardy and persistent grower when once established, it will be very difficult to eradicate. We have a good

illustration of this on the Station. About a month ago we disposed of large quantities of Kikuyu and the patch from which we took the grass three weeks ago was apparently quite clean but now is beautifully green and almost covered with Kikuyu.

(4) Kikuyu is so aggressive that no other plant can grow with it. This is a great advantage because when planted on the veld it will establish itself against any of our veld grasses of minor feeding value.

(5) There is a likelihood of a Kikuyu pasture becoming sod-bound and if this should happen, the field should be disked and ploughed or harrowed.

(6) It is only natural that a plant of such vigorous growth as Kikuyu would soon impoverish the soil.

Kikuyu responds generously to manure, for where there are animal droppings on a patch it will be noticed the grass grows there higher than anywhere else.

Lawns have been grown from this grass around the laboratories of the Botanical Division and on the terraces of the Union Buildings, Pretoria. The bright, light green colour of the foliage forms a lovely setting for ornamental gardening. It will also make an excellent field lawn as it forms a dense, soft and springy turf when closely grazed or clipped.

On account of its ability to grow on practically any type of soil and its creeping characteristics, it should be an excellent soil binder, on dam walls, on sandy soils and on eroding slopes and dongas.

Then again it can be recommended as a grass for planting in a poultry-run. Fowls seem very fond of the leaves, and owing to its aggressive nature it can withstand the ravages of the fowls' scratching, etc.

As Kikuyu is easily propagated by cuttings, it may be either planted by cuttings or "roots." Our practice is to take the grass out in sod, then cut it up into pieces about 3 in. square and plant it out 6 ft. by 6 ft., or 6 ft. distant between the rows and 3 ft. distant in the rows. Our results have shown that when planted 6 ft. by 6 ft. on fairly good soil, it covers the ground in a single season.

Kikuyu being a summer grass the best time of planting is during the spring and summer rains, but it can be planted as late as April when the frosts do not occur before May.

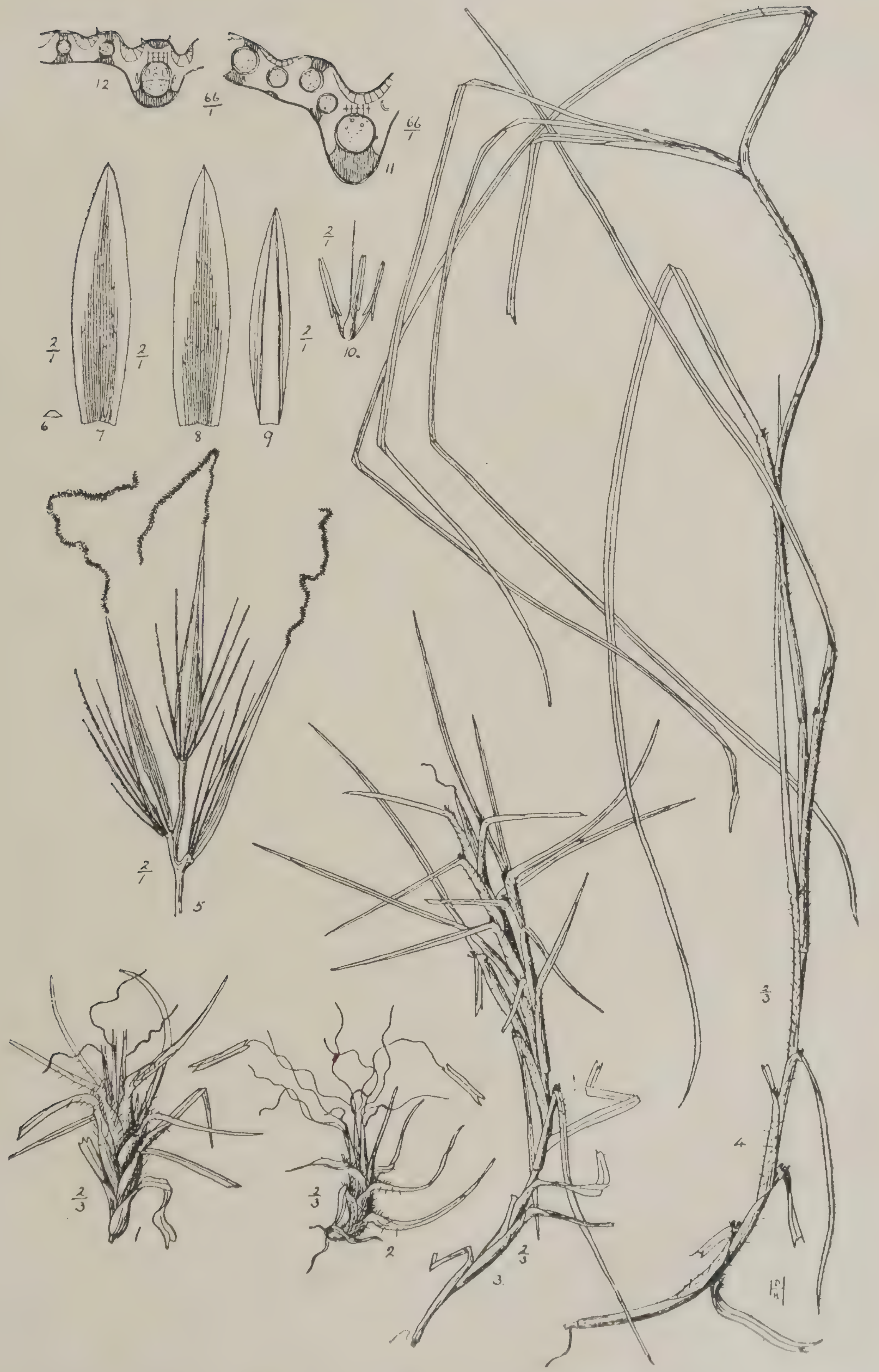
In order to recover the cost of preparing the ground for Kikuyu it is possible after the last cultivation of mealies to put down Kikuyu between the rows."

Subsequently an attempt was made to introduce the grass into Mashonaland. The success seems to have been complete, as may be seen from the following note in the *Rhodesia Agricultural Journal*, XV (1918), p. 327.

" As late sa a year ago it was mentioned in an article in the *Rhodesia Agricultural Journal* (June 1917) that, despite all efforts up to then, no pasture grass had been discovered suitable for Rhodesia which formed a thick bottom and might prove useful for grazing purposes. Since that date, however, our trials with Kikuyu grass (*Pennisetum longistylum*) on the prevailing red soils of Mashonaland have shown that this grass adapts itself perfectly to local conditions, and fulfils all the expectations that have been aroused from reports concerning its behaviour in the Union. The first lot of roots introduced by the Department of Agriculture were obtained from the Potchefstroom experiment farm in March 1917. Through delays, these arrived in a seemingly dead condition, and after a preliminary soaking were planted out. Practically no rain fell after planting, yet by December 1917, considerable growth had been made and the runners became the source of our principal propagation plots. A further lot of slips were imported from Natal in December 1917, and were planted out one foot apart each way. The resulting plot as it appeared in June 1918 is shown in the accompanying illustration. The slips soon covered the ground entirely, and the growth was so vigorous that the paths and adjoining beds were invaded. The spreading power of this grass is one of its most remarkable features, and not only does it spread along the surface of the ground, but its runners penetrate downwards to a considerable depth in the course of a single season, making its hold upon the ground very firm, and rendering it hardy against tramping.

In view of its known excellent feeding qualities, its vigour and its adaptability to Rhodesia, it can be confidently recommended. It is expected that slips in limited quantities will be available for distribution during the coming season."

When in 1915 the first very meagre specimens of the grass reached Kew from Pretoria they were recognized as identical with some fragments of a *Pennisetum* which in 1906 had been received from Mr. A. Linton among pieces of *Cynodon Dactylon* collected at " Linoru " (evidently meant for Lamoru, the first railway station west of Kikuyu). Both were then considered to be probably stunted and very much reduced forms of *Pennisetum longistylum*, a conception corresponding more or less to Leeke's treatment of the plant as a var. *clandestina* of the same species " congrua—et cum forma normali evidenter consanguinea." However, after the accession of better material from East Africa, and the experience gained in the Transvaal, namely, that improved conditions did not affect the peculiar structure of the grass, it became evident that the extreme reduction of the inflorescence and the stunted condition of the vegetative parts were not casual features impressed on the plant by an especially unfavourable habitat, but fixed and perfectly definite characters of specific rank. This was also the conclusion Pilger came to when describing the grass which he had from Lamoru (collected by G. Scheffler in 1909), as a new species, *Pennisetum inclusum* (in *Engler's Jahrb.*, XV, p. 209). Further search in the literature on *Pennisetum*, however, showed that Pilger had been forestalled by Chiovenda who had already in 1903 (*Annuar. Ist. Bot. Roma*, VIII, p. 41) accorded the grass the status of a species, taking up an unpublished name of Hochstetter's " clandestinum " as nomen specificum. Chiovenda's species was based on a specimen of Schimper's, 2084 (no locality stated), which is not represented in the collection at Kew and the British Museum at London, nor was the species itself recorded in the *Index Kewensis*. Chiovenda's description, however, and his figure leave no doubt as to the identity of the plant. Thus the Kikuyu grass will have to be known under the name proposed by him, namely, *Pennisetum clandestinum* Hochst. ex Chiov.



1 and 2, Flowering branches in the female (1) and male stages (from Lamoru, Scheffler, 294). 3 and 4, A flowering (3) and a barren (4) shoot (Groenkloof Botanical Station; cult). 5, A whole inflorescence of a female plant (Groenkloof). 6, Upper glume. 7 and 8, Valves of lower (7) and upper (8) floret. 9, Valvule of upper floret. 10, Rudimentary stamens and ovary of a female plant. 11, Part of a cross section (including midrib) of a blade of *Pennisetum clandestinum*. 12, Same of *Cynodon Dactylon* for comparison.

The two most striking features of *Pennisetum clandestinum* (*see* Figs. 1 and 2 on p. 421) are its stunted growth and proclivity to the formation of very vigorous runners, and the extreme reduction of the inflorescence and its inclusion in the top sheath. In habit it resembles strong specimens of *Cynodon Dactylon* to a remarkable degree, so much so that barren specimens of both may be all but indistinguishable. The anatomical differences are, however, obvious, as will be seen from the cross sections shown on p. 421 (Figs. 11 and 12). Grown in good and well-watered soil it throws up barren stems up to 30 cm. (according to Melle, l. c., even 1 m.) high with elongated internodes (up to 7 cm.) and long slender blades (up to over 20 cm. by 3–4 mm.), whilst the flowering shoots seem to remain short (5–6 cm.) even under such favourable conditions (Figs. 3 and 4). The reduction of the inflorescence (Fig. 5) affects not only the number of spikelets (2–4), but also the involucral bristles which are short, the longest not surpassing three-quarters the length of the spikelet, delicate and eplumose and have evidently lost their function ; further, the glumes, the lower of which is quite suppressed, whilst the upper is merely a small nerveless or almost nerveless scale ; the lower floret which is reduced to its valve and finally the stamens which are occasionally arrested, the flowers becoming thereby functionally female (Figs. 6-10). The valves share the relatively great number of nerves (11–14) with those of *P. longistylum*, but they are narrower, longer, thinner and in the lower part almost devoid of chlorophyll—no doubt in response to their concealed position. The genetic derivation of *P. clandestinum* from *P. longistylum* is obvious, but the power of reversion to its ancestral type seems to have been lost. The reduction of the inflorescences to so few spikelets—and of these sometimes a portion only fertile—must mean poor seeding, a loss amply balanced by the vigour of the vegetative reproduction of the grass by runners and stolons. The area of *P. clandestinum* extends from Eritrea to Mt. Elgon and the highland of West Usambura. *P. longistylum* on the other hand is so far only known from Northern Abyssinia, and the adjoining parts of the Italian colony of Eritrea.

The following is a description of the grass.

Pennisetum clandestinum, Hochst. ex Chiov. in *Annuar. Ist. Bot. Roma*, VIII, 41, t.v., fig. 2 (1903). A hermaphrodite or sometimes unisexual low creeping closely matting perennial with creeping rhizome and slender stolons with very short internodes, throwing up single or more often fascicled short stout branches, the underground portion of which is densely covered with downwards more or less decayed leaf-sheaths. Culms (over-ground stems and branches) very short, often hardly raised above the ground or growing out into long rooting runners appressed to the ground and copiously branching to the right and left with the branches short, stout, closely sheathed and shortly ascending (*see* note on cultivated specimens below). Leaf-sheaths closely imbricate, mostly 1·2–1·6 cm. long, very rarely longer, almost membranous, very pale, then turning brown, distinctly nerved, glabrous or sparingly and shortly hirsute ; ligules reduced to a densely ciliate rim ; blades spreading, linear, gradually passing into the sheath, tapering to a subobtuse point, 1·25–5 cm. by 3–4 mm. (flattened out), tightly folded, then opening out, subsucculent, more or less glaucous, glabrous or sparingly and shortly hirsute, rough on the margins and the subcarinate midrib towards the tip, otherwise smooth, midrib slender, prominent below, primary lateral nerves 2–3, more or less differentiated below only. Inflorescence reduced to a cluster of 4–2 (mostly 3, rarely 1) spikelets, subsessile and enclosed for the greater part in the uppermost leaf-sheath, the terminal spikelet shortly pedicelled, the others sessile, each spikelet supported by an involucre of delicate bristles ; bristles of the terminal involucre up to 15, very unequally long, the longest and strongest about $\frac{3}{4}$ the length of the spikelets, of the lateral involucres similar but much fewer and only on the outer side of the spikelet. Spikelets bisexual or functionally unisexual, slender, linear-lanceolate, 1–1·75 rarely 2 cm. long, glabrous, whitish below, greenish upwards. Lower glume suppressed, upper ovate to ovate-rotundate, subobtuse, up to 2 mm. long, hyaline, obscurely few-nerved. Lower floret reduced to its valve, this lanceolate, long tapering, subacute, as long as the spikelet, thinly membranous, 11–9 nerved. Upper floret ⚥ and markedly protogynous or functionally ♀ with rudimentary stamens ; valve

very similar to that of the lower floret, but slightly shorter; valvule linear-lanceolate, long acuminate, very thin, 4–2-nerved. Lodicules 0. Stamens ⚥ with very long, protruding filaments (up to over 25 mm. long) and dangling anthers, 5–7 mm. long, of the ♀ much reduced with linear-subulate filaments slightly exceeding the ovary and empty anthers, 3 mm. long which remain permanently enclosed in the floret. Ovary obversely pear-shaped, attenuated into the long-exserted filiform style which is up to 3 cm. long, simple or shortly 2-fid and finely plumose from below the middle upwards. Grain (almost mature) dorsally compressed oblong-elliptic in outline, over 2 mm. by 1 mm. long, brown; hilum punctiform, black (Figs. 1–11, p. 421). *P. longistylum* (?) Stapf ex Burtt-Davy in *Agricultural Journal, South Africa*, II (1915), 147. *P. l.* var. *clandestina*, Leeke, *Untersuch. Abstamm. u. Heimat d. Negerhirse*, 23 (1907); Chiov. in *Annuar. Ist. Bot. Roma*, VIII, 319 (1908). *P. inclusum*, Pilger in *Engl. Bot. Jahrb.*, XLV, 209 (1910). *Cynodon Dactylon*, Schweinf. in *Bull. Herb. Boiss.*, II, App. II, 31 (1894), not Pers.

Distribution. Eritrea, Ocule Cusai; by the Dégra stream near Saganeiti, *Schweinfurth* 1257 (barren)! Abyssinia; Samen; Sabra District, Selenka, on dry spots in wet meadows, 2750 m., and at Debra Eski, in dry grassy places, 2870 m., *Schimper* 398! Schoa, Ankober, *Roth* 62! Uganda; Mount Elgon, common on open ground in the bamboo zone, 2600 m., *Dummer* 3614! British East Africa; near Lamoru, *Linton* 215! and near the same place in low bush at 3000 m., *Scheffler* 294! Nairobi, *Dowson* 185! Tanganyika Territory: West Usambara 1600 m., *Eichinger* 3294.

Melle (*see* above) has pointed out that Kikuyu grass in the presence of water will put on top-growth and attain to a height of $2\frac{1}{2}$–3 ft. A specimen from the Groenkloof Botanical Station (H. D. Agr. 19059) shows such a drawn up shoot (Fig. 4). It is about 1 ft. long, with 11 or 12 leaves and the 6th and 7th internodes measure 5 and 6·5 cm. respectively; the corresponding sheaths are roughly of the same length, whilst their blades measure 18 and 23 cm. respectively, by about 5 mm. when unfolded. The accompanying

flowering specimens stand 5 cm. above the ground, with about 7 leaves and blades 3–7 cm. long.

The flowers are as in all the allied species protogynous (Figs. 1, 2). Reduction to a functionally female condition is characteristic of all the cultivated specimens from the Transvaal as far as I have been able to examine them, and it also occurs in those collected by Roth at Ankober; but whilst the anthers of the cultivated specimens were quite devoid of pollen, those from Ankober contained beside some empty pollen grains numerous pollen-mother-cells which had not got beyond the stage of division and were loosely scattered through the anther which had dehisced.

THE MEASURABLE CHARACTERS OF RAW COTTON.*

THE DETERMINATION OF AREA OF CROSS SECTION AND HAIR WEIGHT PER CENTIMETRE.

BY

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INTRODUCTION.

IN comparing different types of cotton it is necessary to evaluate as accurately as possible all characters which are capable of exact measurement. The properties of a yarn depend ultimately on the properties of the single hairs, so that it is important to study the latter in detail. It should be possible from the knowledge gained to predict the behaviour of the raw material in spinning and manufacture, in terms of single-hair properties. This paper supplies data on two of these properties, namely, the mean area of cross section of single hairs, and mean hair weight per centimetre of length.

METHODS.

Sampling. The determination of the mean value of any measurable character in a sample of cotton involves a preliminary study of sampling, since the accuracy of the mean may depend largely on the extent to which the sample is truly representative. It has been shown that groups of thin-walled hairs occur in patches on normal seeds, and that a whole seed may be characterized by thin-walled hairs, if death of the hairs from various causes has taken place before completion of secondary thickening. Balls (*Develop-*

* Reprinted from *Journ. Text. Inst.*, XIV, 12.

ment and Properties of Raw Cotton) has calculated the number of hairs per seed on some Egyptian cottons to be about 8,000. Assuming this number to be approximately accurate for our purpose, there will be, in a given sample of cotton, many groups containing 100 to 8,000 thin-walled hairs scattered sporadically through the sample. Where the size of sample for the determination of any single hair property consists of only a few hundred hairs, it is of great importance to have the thin-walled hairs randomly distributed through the mass. Probably the only accurate way is to select the sample hair by hair from a large number of places, the disadvantage of this system being the amount of time consumed and the eye-strain devolving on the worker. The method adopted in obtaining the results in this paper consisted in collecting a small sample from the amount of material available, and then mixing thoroughly on the draw frame of the Balls sledge sorter.

Cutting sections. For the measurement of area of cross section it is necessary to cut sections from a large number of randomly selected hairs. In practice, half the sample mixed in the draw frame was used for the determination of hair weight per centimetre and the other half for the sections. The latter portion was combed until the hairs were approximately parallel, and a bunch of a few hundred hairs was bound round a wire frame, immersed in alcohol for two minutes to drive out air bubbles, and then transferred to water. An aqueous solution of gelatin, so concentrated as to be quite stiff when cold, was heated over a water bath until fluid. The frame was then placed in a tube and sufficient of the liquid gelatin poured in to cover it completely. The tube and contents were placed for three hours in a warm oven, so that the gelatin remained liquid, and the frame was then immersed in a mixture of 5 per cent. formalin (40 per cent.) and 95 per cent. alcohol, in order to harden the gelatin adhering to the cotton. It was left in the hardening solution for several hours, preferably overnight, and finally placed in absolute alcohol for a few minutes to complete the hardening. The cotton was then cut away from the frame, embedded in vaseline-paraffin, and sections were cut with a hand microtome, and mounted in glycerin-jelly.

For the determination of area of cross section the hairs were drawn on paper at a known magnification, either by use of a microscope and camera lucida, or the projection apparatus. The paper drawings were cut out and weighed, the weight being corrected by means of that of a sheet of standard paper.

RESULTS.

Area of cross section. The area of 20 cross sections was chosen as a unit of convenient size, and the results for 50 groups of 20 obtained for the following cottons :—

(*a*) Trinidad native (T. N. 2), (*b*) U. S. 12–16 (coarse Sea Island), (*c*) Texas (Upland).

The mean area of 20 cross sections was also obtained for Peruvian and for a coarse Peruvian-American hybrid, in each case on 600 sections.

The results are set out in Table I.

TABLE I.

Frequency arrays of areas of cross section of groups of 20 *hairs in units of* 100 *square* μ.

Type ..	.. 22	24	26	28	30	32	34	36	38	40	42	44	46	48	50	52	54	56	58
U. S. 12–16 ..	1	3	7	17	6	5	9	1											
T. N. 2	2	..	3	4	6	17	11	1	3	1	1								
Texas										2	1	5	5	9	16	6	3	1	2

Two further cottons with still greater areas of cross section were worked with. The complete results are summarized below :—

Type	Mean area of cross section of 20 hairs	Probable error	Co-efficient of variability	Probable error of one result
U. S. 12–16 ..	29	±0·30	10·5	±32·8 per cent.
T. N. 2	32	±0·35	11·5	±34·6 ,, ,,
Texas	49	±0·37	7·9	±23·9 ,, ,,
Peruvian	54 on 600	cross sections		
Peruvian hybrid ..	58 ,,	,, ,,		

With the type which showed the greatest probable error, it was normally sufficient to obtain the area of cross section of 132, or say, 140 hairs taken at random, when the maximum probable error of the arithmetic mean was about 3 per cent.

The above results are probably fairly accurate for comparative purposes, but it must not be supposed that they represent the actual areas of cross section, since it is known from a variety of miscellaneous observations that an unknown amount of expansion takes place when a section of a hair is cut, owing to the release of internal tensions. A section cut from one part of a hair may expand more than another section cut from a different part of the hair. Further, the amount of expansion may vary with wall thickness from hair to hair, a hair with thick wall expanding more than one with a thin wall. A rough analogy is provided by a compressed sponge enclosed by a skin ; if a thin section is cut, expansion will take place. From this it will be seen that the determination of the true area of cross section is an almost insuperable problem. Bearing in mind the error involved in the above determinations, it is probable that they are of value (Balls, loc. cit.) for such purposes as the comparison of fineness of various cottons, though the more important quality—degree of variability from hair to hair—would be hidden unless each area of cross section were measured separately, a long and arduous task.

Hair weight per centimetre. It has been pointed out by Balls (loc. cit.) that " although the measurements of this characteristic are not of direct use to the commercial growers or users of cotton as they stand, it is quite possible that some simple, indirect or mechanical method of obtaining the measurements may be devised, and knowledge of them be turned to utilitarian account. The four components which could affect the weight of a lint hair are its length, the thickness of its wall, the density of the cellulose of which the wall is composed, its diameter, and its moisture content .... In general ...... the weight of a hair will depend on its diameter and the thickness of its wall."

Balls made some measurements of this character by cutting uniform lengths out of the middles of samples of hairs, and showed

that the ratio, fibre weight : breaking load, had a value ranging from 2·60 to 3·26, and concluded that the breaking load of a hair is largely determined by its weight, i.e., by the thickness of the cell wall. According to the same author, the probable error of hair weight determinations is high, presumably owing to the sampling difficulty.

Estimations of hair weight per centimetre have been made on the same five cottons, for which data on area of cross section have already been presented. The sample, after having been put in sliver form by passing through the draw frame used in connection with the sledge sorter, was combed and reduced to a group of hairs of convenient mass. A bunch of centimetre pieces was cut from the middle of the bunch with a cutter consisting of two safety razor blades one centimetre apart. Groups of 40 hairs were then weighed separately on a micro-balance, and the results plotted as a frequency curve. The results are presented in Table II.

TABLE II.

Frequency arrays of weights of groups of 40 hairs in milligrams.

	Weights (milligrams)												Mean	Co-efficient of variability
Type	0·048	0·053	0·058	0·063	0·068	0·073	0·078	0·083	0·088	0·093	0·098	0·103		
U. S. 12-16	1	9	17	11	11	1							0·061 ± 0·0005	8·2
T. N. 2 ..	2	5	14	21	7	1							0·061 ± 0·0005	8·2
Texas ..							1	4	20	15	9	1	0·091 ± 0·0005	5·5
Peruvian ..	(on 600 hairs)												0·110	
Peruvian hybrid ..	(on 1,000 hairs)												0·105	

From these results it may be calculated that from 80 to 160 hairs are necessary in order that the probable error of the arithmetic mean shall be about 3 per cent. The assumption is involved that other cottons will not be more variable in respect of the distribution of weights of groups of 40 hairs.

The apparent density of cotton. By the usual accepted methods of determination, the density of cotton is 1·53 to 1·50. Using the data obtained for area of cross section and hair weight per centimetre, the apparent density can be calculated. A preliminary series of observations gave figures for apparent density of 1·0 to 1·2, which indicated that the structure of the cotton hair is porous and not continuous, a conclusion which many botanical workers had already reached on other grounds. It is better to use specific volume instead of density, however, as the amount of pore space can then be expressed as a percentage.

In an Indian cotton, Bharat *kapas*, the specific volume is 0·63 c.c. per gram, using the accepted density figure of 1·50. Actually by calculation from hair weight per centimetre and area of cross section, it is 0·88 c.c. per gram. Thus 0·25 c.c. or 30 per cent. of the volume is pore space. The question thus arises whether different cottons vary in pore space. Determinations for four cottons of widely different degrees of fineness are placed below :—

Type	Apparent density	Specific volume	Pore space, per cent.
T. N. 2	0·97	1·03	37
U. S. 12—16 ..	1·05	0·95	32
Texas	0·93	1·07	39
Peruvian hybrid ..	0·91	1·10	41

It will be seen that the pore space varies from 32 per cent. to 41 per cent., and the variation may either be significant or due to a working error. The area of cross section has already been stated to be too large, owing to the unknown expansion which takes place when the hair is cut, and there seems to be no way of finding out

whether the expansion is greater for a coarse cotton than a fine. Greater expansion on the part of the coarse cottons would result in a lower apparent density and a higher specific volume. Bearing in mind, however, the working error, the provisional conclusion may be stated that the finer the cotton, that is, the lower the area of cross section, the greater the apparent density and the lower the porosity.

Work on bleached cottons would show whether the variations in porosity observed are related to differences in dyeing properties, but such differences would be most easily detected by actual dyeing experiments.

Summary.

1. The necessity for quantitative investigations on the properties of single hairs is emphasized, and methods for the evaluation of mean area of cross section and hair weight per centimetre are described.

2. To obtain a mean value subject to a maximum probable error of not more than 3 per cent. of the mean entails great care in sampling, and the following minimum number of observations :—

140 for area of cross section,
80 to 160 for hair weight per centimetre.

3. Data on area of cross section and hair weight per centimetre are presented for five cottons, but the existence of an unknown amount of expansion when the hair is cut renders the figures for area of cross section of doubtful value except for comparative purposes.

4. Calculations of specific volume, apparent density, and porosity of four cottons show that the amount of pore space varies from 32 per cent. to 41 per cent. and, in general, the amount of pore space increases with the coarseness of the cotton.

Notes

IRRIGATION AND INTERCULTIVATION.

For some years the writer has been considerably interested in the conflict between irrigation and intercultivation of crops. In any irrigation scheme the general slope of the land must be sufficient for the water in canals and feeding channels to flow steadily ; but the surface of each plot to be irrigated must be almost level ; so that, in practice, either expensive grading is necessary or the plots are small because of the numerous contour ails necessary to hold the water approximately at the same depth all over the plot. Usually a compromise between the two is arrived at, but almost always the individual plots are too small to allow of intercultivation of the growing crop by bullock-drawn implements. It is generally agreed that heavy irrigation followed by cultivation, at longer intervals, is better practice than applying the same amount of water in smaller doses at shorter intervals : but, with the usual systems of irrigation, only hand cultivation is possible and this is very expensive and generally badly done ; so in practice it is very often omitted and, instead, more water is given when the soil looks dry. Water is probably generally cheaper than hand labour.

Intercultivation by cattle connotes turning space at the ends of the rows and a certain minimum length of rows to keep the time occupied in turning as against that employed in actual cultivation at a reasonably low figure. The turning space may not be entirely wasted from cultivation as a catch crop may be sown when the main crop is too large for further cultivation. Probably from these points of view 10 chains is a convenient minimum length of plot.

The matter is further complicated in the cultivation of drained lands in Chota Nagpur for sugarcane by the fact that we want the lands sufficiently sloped for free surface drainage in the monsoon.

If the slope is sufficient for really good surface drainage, there will be heavy wash if the furrows are too long. In practice a slope of 6 to 9 inches in 100 feet and furrows about 10 chains long seems satisfactory, and of course the steeper the slope the shorter the furrows.

These furrows are usually irrigated by turning into one the stream from whatever is the water supply and letting it flow till it looks as if it will reach the other end. Then that furrow is closed and the stream turned into the next, and so on. A coolie is required to turn the stream from one furrow to the next and watch for bursts in the furrows, etc. Often, on land where the furrows are ill-defined or shallow, two or three coolies are kept busy keeping the stream in its proper furrow. Scouring, exposure of cane setts and waste of water seem inevitable if the supply of water is at all ample.

A system of automatic irrigation is mentioned in the "Agricultural Journal of India" (Vol. XIX, Part II) and more fully described in the Bulletin of the Hawaiian Sugar Planters' Association on "The Irrigation of Sugarcane in Hawaii," and the writer has been experimenting with the adoption of the principle in some of his cane irrigation. The field in which the attempts were made is 2·2 acres, 11 chains long and 2 chains wide with a slope of about 9 inches per 100 feet, not yet uniform, and the cane is newly planted in furrows running the length of the field and 4 feet apart. The water supply is at present free flow from a tank above, through 2 inches pipe running full. Formerly by running the whole flow into successive single furrows we irrigated 10 furrows per day. Two coolies were kept busy controlling the water, setts were exposed, some scouring occurred and the furrows were dry enough to cultivate on the second day after watering.

Now we have made furrows across the end of the rows at the high end of the field with their boundary ails horizontal. Each furrow commands 8 lines of cane. A little water was run into the first cross furrow and then 8 pipes (uncut country tile pipes of 2 inches mouth) were placed in the ail next the cane, all exactly at water level, and the supply pipe was opened. As the cross furrow filled, a trickle of water flowed through each pipe and seeped, rather than

flowed, along the cane row. The whole was then left to look after itself. Occasionally the jemadar, *gur*-making in the next plot, wandered over; and if he saw the flow of water in one furrow lagging behind the others lowered its pipe a little. In the evening the water had seeped to the end of the 8 rows of cane, and judging by the side seepage into the ridges each line had a very thorough irrigation. There was no scouring or exposure of setts, no coolies had been employed except for an hour in the morning starting up, and the furrows were not dry enough to cultivate till the third day after watering, when a good cultivation was given. Most of the setts have germinated and the next irrigation 17 days later found the soil very damp 3 inches below the surface.

Of course there are probably various drawbacks. For instance, the actual amount of water seeping into the soil probably varies largely at the two ends of the furrow, and it may be difficult to get heavy irrigations on to the land by this method. Increasing the period of flow into the furrows and adjusting it so that it just reaches the far end without serious overflowing would help both. But there is almost certainly an optimum length of furrow for any particular slope and texture of soil. It seems likely, however, that, working on some such system as this, we can effect a reasonable compromise between irrigation and cultivation, not only for young cane but for other crops grown in lines such as cotton and vegetables, and incidentally make better use of our available supply of water and economize considerably in hand labour. [A. P. Cliff.]

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A GALL-FORMING THRIPS ON *CALYCOPTERIS FLORIBUNDA*: *AUSTROTHRIPS COCHINCHINENSIS*.*

The writer had occasion to visit the Taliparamba Pepper Farm, Malabar, in May 1923 and later on in September-October 1923, and in the course of an examination of the various wild plants on the farm he came across certain characteristic galls on one of

* Note read at the Zoological Section of the Indian Science Congress, Bangalore, 1924.

the wild plants there, viz., *Calycopteris floribunda* (Nat. Ord. Combretaceæ). This plant is a small shrub generally growing into a bush and is said also to put forth long branches in favourable places whereby it climbs trees like a twiner. The plant goes under the local name of "Pullani" in Malayalam. The galls are when full-formed rather large structures reaching a length of two to two and a half inches, generally roughly elliptical in outline, somewhat flattened, but with the surface deeply wrinkled and convoluted. They were generally found formed at the axils of the leaves. A close examination revealed the fact that the gall was in reality a bag-like structure and that they invariably showed the presence inside of numerous specimens of a small black thrips in different stages of development—little elongate oval whitish eggs, the pale greyish larvæ, and the mature black adults. In very old specimens abundant signs of the attack of a Pyralid caterpillar (not reared) were noticeable.

During the second visit in September-October 1923, the writer met with numerous examples of the galls in the incipient stages of growth. An examination of such young galls—which were noted in various stages of development—and a careful dissection of those structures have induced him to come to certain conclusions as to the nature and origin of those extraordinary structures, which it is the object of this paper to point out.

These galls are almost invariably axillary in their position—being almost always found borne at the axils of the leaves—a terminal position, though it may occur, is rather uncommon. In the older galls the tissues are so overgrown and malformed that it is not easy to say which part of the healthy plant the gall represents. It looks more like a malformed fruit than anything else. In the earlier stages, however, evidences are more clear as to what it really is. In the half-formed ones the swelling is distinct and is borne on a stalk which it is easy to recognize as the stem of the young shoot. At the tip of the gall the rudiments of the young leaves of the shoot are clearly recognizable. The gall itself is a hollow structure communicating with the outside by a small hole between the leaf rudiments at the tip and is lined inside by a hairy epithelium (?)

as in the case of the surface skin of the young shoot. This hollow structure is invariably peopled by varying numbers of the adult thrips and in addition contains numerous eggs and young ones of the same thrips. In instances of still earlier stages of development, the gall is but slightly formed, but is still a sort of hollow stalk in which 2 or 3 thrips are busy laying eggs and rearing their offspring. In a few cases very young buds in which an adult thrips was insinuating itself between the young rudiments of the leaves at the tip were also noticed. From these observations it appears to the writer to be clear that when fresh shoots are put forth by the plant after the monsoon, the adult thrips come out of their places of hiding inside old galls and go in search of young shoots. They crawl between the leaf rudiments at the tip, and reach the growing bud in which they appear to attack the meristematic tissues in such a way that while the central part ceases to grow, the sides begin to lengthen and ultimately cause the formation of a pocket-like structure at the tip of the growing shoot. The gall is therefore a bud or shoot gall—in which the development of the growing point is checked and a hollow outgrowth is formed carrying at the tip the leaf rudiments. The colony of thrips lives inside these hollow galls, breeds and increases.

The situation is often complicated by the fact that a Cecidomyiid maggot also causes blister-like galls in the young leaves of this plant and such galls are also found on the walls of these Thripid galls.

These galls were called " Fruits " by the people about Taliparamba and are known to have medicinal properties, being used in preparations for skin diseases by the local physicians.

These galls were found by Mr. T. V. Ramakrishna Ayyar at Mundakayam and Tenmalai in Travancore and reported to be used similarly for skin troubles, and were recently collected by Mr. J. A. Muliyil from Gurpur in S. Kanara District, and it is probable that this thrips will be found throughout the West Coast.

The writer is indebted to Prof. H. Karny, Zoological Museum, Buitenzorg, for his kind identification of these thrips. He described this species from specimens collected in South Siam and Cochin-China. [Y. Ramachandra Rao.]

FIRST PLANT BREEDERS' CONFERENCE, BOMBAY.

In the Bombay Presidency, plant breeding as a separate activity of the Agricultural Department has of recent years greatly increased in importance and in personnel. It was felt that the time was now ripe for a conference of all those engaged in this branch of scientific work, and accordingly the First Plant Breeders' Conference met at the College of Agriculture, Poona, on April 14, 15 and 16, 1924.

The members of the conference were thirty-one in all, and included the Plant Breeding Expert and his graduate staff, the Cotton Breeders, the men specializing in the breeding of rice, sorghum, wheat, tobacco, and inferior millets, the Horticulturist and his staff, and the Economic Botanist and his staff. Dr. W. Burns, Principal of the College of Agriculture, presided throughout the gathering. Dr. H. H. Mann, Director of Agriculture, Bombay Presidency, opened the proceedings with an address emphasizing the need for severe scientific treatment of our problems and the success hitherto achieved. A variety of papers were presented and discussed, the most important and most discussed subject being the interpretation of the results of field experiments. The recent work[1] of Faulkner, Sarkar, Parnell and Leslie Lord was freely cited in this connection, and much illuminating original information was supplied from the work of the members of the conference. Work done on special crops was reported and criticised, certain methods of standardizing methods and measurements were agreed on, and a recommendation made that the meeting should be an annual fixture and the next meeting be held in Surat. The social side was not neglected, the members entering into the college games and also entertaining to tea Dr. and Mrs. Mann who were about to proceed on leave.

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FIGHTING THE BOLL-WEEVIL: RENEWED AMERICAN CAMPAIGN.

A special correspondent in Washington writes in "The Times Imperial and Foreign Trade and Engineering Supplement."

[1] *Agri. Jour. India*, XIV, 5; XVIII, 3; XVIII, 5; XIX, 1.

No. 304 :—

Stabilization of cotton production through the control of the boll-weevil is the object of an aggressive movement just launched by the combined business interests of the United States, as represented in the Chamber of Commerce of the United States. The drive against the boll-weevil will be conducted under the auspices of the National Chamber's Agricultural Bureau, in co-operation with 130 local chambers of commerce in the cotton belt.

In a statement announcing the movement the National Chamber pointed out that "a steady decline in the production of cotton, accompanied by an increase in the price of the American staple, has been reflected in increasing activity on the part of the foreign Governments to develop potential cotton areas outside the United States, as well as in a slackening of demand for finished mill products. Students of the situation are asking whether at the present rate of production of cotton in the United States the world demand for the raw product can be met unless new cotton areas are brought into play. While we do not believe that there is any immediate danger of the United States losing its position of dominance in the world cotton markets, yet we are convinced that the situation demands more aggressive efforts to stabilize production."

The National Chamber will supply local chambers of commerce in the cotton belt with information for use in the campaign, including the following :

(1) Facts and figures showing the trend of world supply and of demand for raw cotton ;

(2) Material indicating the part played by export cotton in the preservation of the national trade balance ;

(3) A survey of the possibilities of increased production of cotton in foreign lands ;

(4) Data showing the steadily increasing consumption of American cotton by our own mills, with the proportionate falling-off in our cotton exports.

Information concerning the methods of weevil control and the manner of applying them and the work that is being done by banks and commercial organizations to stimulate the movement

will be distributed, and the Agricultural Bureau will act, as far as possible, as a clearing-house for all member organizations. The Bureau is now devising a plan for organized stalk-destruction in the autumn.

Six million bales lost yearly.

In furtherance of the movement, Mr. Julius H. Barnes, President of the National Chamber, has just issued a statement dealing with the present cotton situation from a number of important angles. Mr. Barnes's statement, which showed that in 1923 the United States exported 13 per cent. less cotton than in 1922 and 37·8 per cent. less than the pre-war average, aroused the business interests of the country to the importance of the campaign. It was further shown by Mr. Barnes that the boll-weevil now is preventing production to the extent of about 6,000,000 bales a year. He added that this falling-off of exports of an item which played so important a part in the maintenance of the American trade balance was a matter of national concern.

On the important subject of the boll-weevil Mr. Barnes's statement says :—

This insect, though it became established on our side of the Rio Grande River in 1892, did not seriously curtail production of cotton before 1914. This is explained by the fact that increased production of cotton in the area which up to that time was not infested by the weevil offset the damage wrought in the area occupied by the pest. However, since 1914 the real blight of the insect has been felt. In that year we made our record yield of 16,000,000 bales. Since then production steadily has decreased in spite of increased acreage. Between 1896 and 1914 the average per acre yield of cotton in this country was 188 lb. ; between 1915 and 1923 this yield shrunk to an average of 155 lb.

Remedy for the pest.

We do not agree with the British report that there is no real remedy for the boll-weevil. After many years of painstaking research which has given us more scientific data on the boll-weevil

than perhaps on any other insect, there has been evolved a method by which cotton can be produced in spite of the invader.

Briefly summarized, this method calls first for maintenance of soil fertility in order to secure a high normal production, and the use of early maturing varieties of cotton and intensive cultivation so that maturity of the fibre may be brought about in the shortest possible time, thus to win the annual race against the weevil. These methods are absolutely essential for a maximum yield of cotton regardless of the weevil, but in addition to and in conjunction with these the use of an arsenical poison has been demonstrated to yield most encouraging results.

In October 1923, at the call of the Louisiana State Bankers' Association, there was held in New Orleans a convention for the purpose of organizing more aggressive action against the weevil. This convention premised its deliberations upon the fact that cotton production in America not only is a national problem but an international problem as well. Out of this convention arose the National Boll-Weevil Control Association, which has been put on a relatively permanent basis for the purpose of utilizing all possible agencies in the task of awakening industry as well as agriculture to the importance of stabilizing cotton production through more effective weevil control. This organization is furnishing chambers of commerce, banks, and other organizations and individuals with the A B C of boll-weevil control methods as finally agreed upon by both this association and the Association of Southern Agricultural Workers, which made a careful study of the various control measures now in use.

Because of the interdependence of agriculture and industry it is the common privilege of both these great groups to strive for stabilization of cotton production in this country. It is of vital concern to the banking interests of the East no less than to those in the South that cotton shall retain its place among the foremost items of export contributing to our American trade balance.

Such opportunities to drive home the necessity for better weevil control as lie within reach of chambers of commerce, bankers' and manufacturers' associations, and other groups should be seized

upon and made the most of. The Chamber of Commerce of the United States has taken due cognizance of this national problem, and through it the Agricultural Bureau has planned an aggressive campaign which may aid in placing American cotton beyond the danger of losing its dominant position in the world market. Not as an independent organization but through the hearty co-operation of its member organizations throughout the cotton belt, the National Chamber hopes to render agriculture and industry this aid.

Mr. Barnes also pointed out that in the United States the labour problem was one great limiting factor in the possibilities of extending the cotton area. When it was remembered that, as compared with corn, the amount of labour required for the production of an acre of cotton was 107 hours as against 18 hours, and that 68 per cent. of the labour in producing cotton fell before the time of harvest, it would be seen what an item this was.

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A TREE-PLANTING MACHINE.

ATTENTION is drawn in the February (1924) Number of "South African Journal of Industries" to a recent invention designed to facilitate the planting of trees. It is known as the Duivel Tree-Planter, and the principle on which it works is that of taking up the rich nursery soil around the young tree, with the tree in the centre, and planting the whole in the position which the tree is to occupy permanently. The roots are thus left undisturbed, and the tree suffers nothing from its change of position. The removal is accomplished by means of a cylinder which is placed around the tree and pushed down into the soil. By this means a young tree can be removed with a block of soil round its roots nine inches deep and nine inches in diameter. The cylinder is then planted in the designed spot and withdrawn. It is claimed that a young tree can be planted out with the Duivel machine in the hottest sun at any season of the year without suffering any serious setback. [*Jour. Royal Soc. Arts*, No. 3729.]

COTTON GROWING IN AUSTRALIA.

We have received the following for publication :—

An authoritative article dealing with the present position of cotton-growing in Australia and the possibility of the Dominion becoming an important source of supply is published in the current issue of the "Bulletin of the Imperial Institute" (XXI, 4). The author, Mr. W. H. Johnson, who was at one time Director of Agriculture in the Southern Provinces, Nigeria, recently paid a visit to Australia to report on the suitability of different parts of the country for cotton cultivation.

In 1788, Governor Philip brought cotton-seed from South America to plant in Sydney, and since then many attempts have been made to grow cotton in Australia. The first bale of cotton exported from the Dominion was produced in Queensland in 1852. With the help of premiums paid by the Government and the high prices ruling as a result of the American Civil War, production increased and, in 1871, shipments from Queensland amounted to 2,602,100 lb. Subsequently, the industry declined, and, with the exception of a slight revival in 1890, remained practically dormant until the last few years. Considerable interest has now been again aroused. The Queensland Government are encouraging the growth of the industry by providing cotton-seed free of charge for planting purposes, and by paying farmers a guaranteed price for seed-cotton ; assistance is also being rendered by the British Cotton Growing Association. In 1922, an area of 7,000 acres were planted with cotton in Queensland and the yield of seed-cotton by the end of August had amounted to over $3\frac{3}{4}$ million lb. Mr. Johnson discusses the problems confronting the planter in the various regions where cotton-growing has been proposed and concludes that the soil and climatic conditions in large portions of Queensland, Northern New South Wales, North-West Australia, and in the Irrigation Settlements of Victoria, New South Wales and South Australia, are well adapted for cotton cultivation, but carefully conducted trials will be necessary to decide whether the crop can be grown profitably on a large commercial scale.

COTTON-WILT : A SEED-BORNE DISEASE.

The following is a summary of a paper by Mr. John A. Elliott in the *Jour. of Agri. Res.*, XXIII, 5 :—

The cotton wilt organism, *Fusarium vasinfectum*, Atk., was isolated from strongly surface-sterilized cotton-seed, indicating that the organism is at times carried on the inside of the seed-coat. The pathogenicity of the organism was proved by inoculation experiments. Artificially inoculated seed carried the viable organism on the seed lint for at least five months. The wilt disease was introduced into wilt-free soil by means of artificially infected seed. It is recommended that badly infected fields be rejected as a source of seed for planting.

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RESTRICTIONS ON IMPORT OF PLANTS FROM INDIA INTO SCOTLAND.

In amplification of Notification No. 360, dated 29th February, 1924 (*Agri. Jour. India*, XIX, 3, p. 327), it is notified by the Government of India in the Department of Education, Health and Lands (No. 825, dated 12th June, 1924) that a Destructive Insects and Pests Order has also been passed by the Board of Agriculture for Scotland, dated 23rd June, 1922, the terms of which are the same as the Destructive Insects and Pests Orders made by the Agricultural Departments of England, Northern Ireland and the Irish Free State. The arrangements published in the above Notification which have been made in India for the inspection and certification of plant consignments intended for export to England, Wales, Northern Ireland and the Irish Free State will also be applicable to plant consignments intended for export to Scotland, the original of the certificate covering which should be forwarded by the exporter to the Board of Agriculture for Scotland, York Buildings, Queen Street, Edinburgh.

PERSONAL NOTES, APPOINTMENTS AND TRANSFERS, MEETINGS AND CONFERENCES, ETC.

His Majesty the King-Emperor's Birthday Honours List contains the following names which will be of interest to the Agricultural Department :—

Knighthood. The Hon'ble Mr. M. S. D. Butler, C.B., C.I.E., C.V.O., C.B.E., I.C.S., President, Council of State.

C.S.I. Mr. Frank Noyce, C.B.E., I.C.S., Secretary to Government, Development Department, Madras.

Rao Bahadur. Mr. Pandurang Chimnaji Patil, M.Sc., L.Ag., Deputy Director of Agriculture, South Central Division, Bombay.

Rai Sahib. Babu Srish Chandra Banarji, F.C.S., Offg. Assistant Agricultural Chemist, United Provinces.

Babu Haridas Banarji, Head Assistant, Office of the Director of Agriculture, Bengal.

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Mr. J. W. Bhore, C.I.E., C.B.E., I.C.S. (Madras), has been appointed Secretary to the Government of India, Department of Education, Health and Lands, *vice* Sir Montagu Butler appointed President of the Council of State.

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Mr. M. S. A. Hydari, I.C.S. (Madras), has been appointed to officiate as Under-Secretary to the Government of India, Department of Education, Health and Lands.

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Dr. W. H. Harrison, D. Sc., has been appointed to officiate as Agricultural Adviser to the Government of India and Director, Agricultural Research Institute, Pusa, *vice* Dr. D. Clouston, C. I. E.,

granted leave for 3 months and 25 days. Dr. W. McRae officiates as Joint Director of the Institute and Mr. J. N. Mukerjee as Imperial Agricultural Chemist.

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Mr. M. Wynne Sayer, B.A., Secretary, Sugar Bureau, Pusa, has been appointed to officiate as Imperial Agriculturist from 5th June, 1924, *vice* Mr. G. S. Henderson on other duty. Mr. Arjan Singh officiated as Imperial Agriculturist from 14th April to 4th June, 1924.

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Mr. E. J. Bruen, Deputy Director of Agriculture for Animal Breeding, Bombay, has been appointed to officiate as Imperial Dairy Expert, Bangalore, *vice* Mr. W. Smith granted leave for six months from 25th April, 1924.

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Mr. T. F. Main, B.Sc., Deputy Director of Agriculture, Bombay, has been appointed to officiate as Director of Agriculture, *vice* Dr. Harold H. Mann granted leave for six months.

***

Dr. W. Burns, D.Sc., Economic Botanist to Government, Bombay, has been confirmed in his appointment as Principal, Agricultural College, Poona.

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On the retirement of Mr. J. B. Knight, M.Sc., from 19th April, 1924, Mr. B. S. Patel, B.Ag., N.D.A., N.D.D., has been appointed Professor of Agriculture, Agricultural College, Poona.

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Mr. B. S. Patel, B.Ag., N.D.A., N.D.D., Professor of Agriculture, Agricultural College, Poona, has been appointed to officiate as Deputy Director of Agriculture for Animal Breeding, Bombay, *vice* Mr. E. J. Bruen on other duty.

Mr. V. G. Gokhale, L.Ag., Deputy Director of Agriculture, Bombay, has been appointed to officiate as Professor of Agriculture, Agricultural College, Poona, *vice* Mr. B. S. Patel on other duty.

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Mr. M. K. Pawar, B.Ag., has been appointed to officiate as Deputy Director of Agriculture, Konkan, *vice* Mr. V. G. Gokhale on other duty.

***

Rao Saheb Bhimbhai M. Desai has been appointed to act as Deputy Director of Agriculture in the Indian Agricultural Service, Bombay, from 19th April, 1924, the date of retirement of Mr. J. B. Knight.

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Mr. T. Gilbert, B.A., Deputy Director of Agriculture, Sind, has been granted combined leave for 15 months and 7 days from 1st September, 1924.

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Mr. W. M. Schutte, A.M.I.M.E., M.R.A.S.E., Agricultural Engineer to Government, Bombay, has been granted leave on average pay for six months from 1st July, 1924.

***

Mr. C. S. Patel, B.Ag., has been appointed to act as Deputy Director of Agriculture, North Central Division, Bombay, *vice* Mr. W. J. Jenkins granted leave.

***

Mr. F. R. Parnell, M.A., Government Economic Botanist, Madras, has been permitted to retire from the Indian Agricultural Service from the date of expiry of leave granted to him.

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Mr. B. Viswanath, Officiating Government Agricultural Chemist, Madras, has been admitted a Fellow of the Institute of Chemistry in London (F. I. C.), as a result of examinations held a few months ago.

Mr. D. Anand Rao, B.Sc., Deputy Director of Agriculture, Madras, and Rao Saheb T. S. Venkatraman, B.A., Government Sugarcane Expert, Coimbatore, have been confirmed in the Indian Agricultural Service from 10th June, 1924. Mr. Anand Rao was on leave for one month from 1st June, 1924.

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Mr. C. Tadulinga Mudaliyar, F.L.S., who has been promoted to the Indian Agricultural Service from 3rd September, 1923, has been appointed Lecturing and Systematic Botanist, Agricultural College, Coimbatore.

***

Mr. F. Ware, M.R.C.V.S., Chief Superintendent, Civil Veterinary Department, Madras, has been granted an extension of leave on half average pay for 14 months and 12 days from 11th October, 1924, in lieu of study leave for 4 months previously granted to him.

***

Mr. T. J. Hurley, M.R.C.V.S., Officer in charge of the First Circle, Civil Veterinary Department, Madras, has been appointed to officiate as Professor of Surgery, Madras Veterinary College, from 1st July, 1924, *vice* Mr. P. T. Saunders on other duty.

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Mr. P. T. Saunders, M.R.C.V.S., Professor of Surgery, Madras Veterinary College, has been appointed to officiate as Professor of Pathology and Bacteriology, *vice* Mr. V. Krishnamurthi Ayyar deputed to the Imperial Bacteriological Laboratory, Muktesar, for training.

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In modification of a previous notification, Mr. A. C. Dobbs, B.A., Director of Agriculture, Bihar and Orissa, has been granted leave on average pay from 28th April to 25th October, 1924.

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The services of Dr. H. M. Leake, Sc.D., M.A., Director of Agriculture, United Provinces, on deputation under the Government

of Soudan, have been replaced at the disposal of the Government of the United Provinces from 21st May, 1924. He has been granted leave on average pay for three months from the date of reversion.

***

MR. C. P. MAYADAS, M.A., B.Sc., Principal, Agricultural College, Cawnpore, was on leave on average pay from 18th April to 1st June, 1924, Mr. P. B. Richards officiating.

***

SYAID MUHAMMAD RAZA HUSAIN has been appointed to officiate in the Indian Agricultural Service as Deputy Director of Agriculture in charge of Cattle Breeding Operations, United Provinces, from 15th May, 1924, *vice* Mr. C. H. Parr granted leave.

***

MR. T. A. MILLER BROWNLIE, C.E., M.I.M.E., Agricultural Engineer to Government, Punjab, and Offg. Principal, Punjab Agricultural College, Lyallpur, has been granted leave on average pay for four months from 1st June, 1924.

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SARDAR SAHIB KHARAK SINGH, M.A., Associate Professor of Agriculture, Punjab Agricultural College, Lyallpur, has been granted leave on average pay for two months from 21st May, 1924.

***

MR. MUHAMMAD ABDULLAH has been appointed to officiate as Deputy Director of Agriculture, Gurdaspur Circle, Punjab, *vice* Malik Sultan Ali granted leave.

***

COLONEL G. K. WALKER, C.I.E., O.B.E., F.R.C.V.S., Principal of the Punjab Veterinary College, Lahore, has been granted leave on average pay for 2 months and 27 days from 3rd April, 1924, combined with the college vacation, Mr. W. Taylor, M.R.C.V.S., officiating.

On return from leave, Mr. Leslie Lord, B.A., Deputy Director of Agriculture, Burma, has been posted to the charge of the Northern Circle with headquarters at Mandalay.

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On relief by Mr. Leslie Lord, Mr. W. M. Clarke, M.B.E., B.Sc., has been appointed Professor of Agriculture, Agricultural College, Mandalay.

***

Dr. S. K. Mitra, M.Sc., Ph.D., has been confirmed in the Indian Agricultural Service and in his appointment as Economic Botanist, Assam, from 28th February, 1924.

***

Mr. J. N. Chakravarty, B.A., M.S.A., M.R.A.S., Deputy Director of Agriculture, Assam, has been granted leave on average pay for one month from 1st June, 1924, Srijut L. Barthakur officiating.

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In consequence of certain vacancies caused by the retirement of nominated members, the following have been nominated to be members of the Indian Central Cotton Committee, Bombay :—

Mr. B. F. Madan to represent Co-operative Banking.

Mr. H. T. Conville to represent the Punjab Cotton Growing Industry.

Mr. R. C. Broadfoot to represent the Madras Agricultural Department.

Mr. G. Z. Meli, to represent the Chamber of Commerce, Tuticorin.

Reviews

Practical Botany.—By Diwan Bahadur K. RANGACHARI, M.A., L.T. (Madras: Superintendent, Government Press.)

WE cordially welcome this book which is the third of the publications recently contributed by the author to the study of Indian botany. It is prepared from the material handled by the author and his colleagues for the exercises which were taught to successive batches of students of the Agricultural College and Research Institute at Coimbatore. The book, which is divided into three sections dealing with Morphology, Physiology and Cryptogams, quite appropriately forms a valuable laboratory supplement to the author's excellent "Manual of Elementary Botany for India."

We have read over the book with great interest and find it to be an extremely useful guide to the students of practical botany, even of advanced classes, and it is more so to the teachers and demonstrator. The selection and preparation of plant materials and objects leaves nothing to be desired. There are appropriate illustrations in the three sections and some good microphotographs are also reproduced. The latter are extremely useful. Their value would have been further enhanced had they been supplied with explanatory references by pointed lines to the contents. This want is more particularly felt in the case of Figs. 1, 5, 11. In the portion on physiology, one would expect to see more illustrations. There are none of the latter to explain experiments of photosynthesis. Such were specially necessary for experiments 7, 9, 5(*b*).

The four appendices, giving a list of apparatus, micro-technique, etc., provide all detailed information that may be needed for fitting up a botanical laboratory that will serve the purpose of the teacher and the taught.

The author's method of treatment of the subject discloses his appreciation of the difficulties of the students and his consequent endeavour to make the instructions clear at each step. As the student progresses in the study of practical botany as presented in this book, more and more interest in the study is awakened in him to pursue the subject. The writer's aim mentioned by him in the preface—of not compelling the student to discover things for himself but of *helping* him by giving clear instructions and guidance—has been very well accomplished.

The book is a valuable addition to the literature on Indian botany and we commend without hesitation this book to students and to teachers. [G. B. P.]

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Some Studies in Bio-Chemistry.—By Some Students of DR. GILBERT FOWLER, D.SC. Pp. 197. Illus. (Bangalore: The Phœnix Printing House.)

THIS publication is a collection of 26 short articles and studies in industrial and bio-chemistry, dedicated to Dr. Fowler on the eve of his retirement from the chair of bio-chemistry at the Indian Institute of Science, by the authors, some of his former students.

The range of subjects discussed is very wide, including, as it does, problems connected with such raw materials and products of industry as acetone, alcohol, fibres, lac, manures, edible oils, leather and tannery products, and gives the reader a slight idea of the number and variety of problems connected with industry in India, the solution of which cannot be expected to be found without the work of bacteriologists and bio-chemists. [J. H. W.]

NEW BOOKS

ON AGRICULTURE AND ALLIED SUBJECTS

1. The Soil and its Management, by Merritt F. Miller. Pp. vi+386. (Boston and London : Ginn & Co.) Price, 7*s*. 6*d*. net.
2. Beasts of an Indian Village : A popular account of the Common Back-boned Animals of an Indian Village, by Douglas Dewar. Pp. viii+132+9 plates. (London, Bombay, Calcutta and Madras : Oxford University Press). Price, 4*s*. 6*d*. net.
3. Farm Equipment for Mechanical Power, by Frank N. G. Kranich. Pp. xv+405. (London : Macmillan & Co., Ltd.) Price, 12*s*. 6*d*. net.
4. The Production of Field Crops : A Text-book of Agronomy. Pp. 514. (London and New York : McGraw-Hill Publishing Co.) Price, 17*s*. 6*d*.
5. Butterflies of India, by Chas B. Antram, F.E.S. Pp. xvi+226+412 figs. (Calcutta and Simla : Thacker, Spink & Co.) Price, Rs. 30.
6. Economic History of American Agriculture, by Prof. E. L. Bogart. Pp. x+173. (London : Longmans, Green & Co.) Price, 6*s*. net.
7. Manuring of Grass Land for Hay, by Winifred E. Brenchley. Pp. viii+146. (London : Longmans, Green & Co.) Price, 12*s*. 6*d*. net.
8. Grassland Farming, Pastures and Leys, by W. J. Malden. Pp. xxiv+314. (London : Ernest Benn, Ltd.) Price, 30*s*. net.
9. Quantitative Agricultural Analysis, by E. G. Mahin and R. H. Carr. (International Chemical Series.) Pp. xiii+329. (London : McGraw-Hill Publishing Co.) Price, 13*s*. 9*d*.

The following publications have been issued by the Imperial Department of Agriculture in India since our last issue :—

Memoirs.

1. Studies in Indian Tobaccos. No. 4. Parthenocarpy and Parthenogenesis in the varieties of *Nicotiana Tabacum* L. var. *Cuba* and var. *Mirodato*, by Gabrielle L. C. Howard, M.A., and Kashi Ram. No. 5. The Inheritance of Characters in *Nicotiana rustica* L., by Gabrielle L. C. Howard, M.A. (Botanical Series, Vol. XIII, No. 1.) Price, Rs. 2 or 2*s*. 9*d*.
2. The Wilt Disease of Safflower, by S. D. Joshi, B.Sc. (Botanical Series, Vol. XIII, No. 2.) Price, R. 1 or 1*s*. 6*d*.

Bulletin.

3. The External Morphology and Bionomics of the Commonest Indian Tick (*Hyalomma ægyptium*), by Mohammad Sharif, M.A., F.R.M.S. (Pusa Bulletin No. 152.) Price, R. 1.

Report.

4. Report of the Proceedings of the Fifth Entomological Meeting, held at Pusa from 5th to 10th February, 1923. Price, Rs. 9-8.

THE ROSE-RINGED PAROQUET (*PSITTACULA TORQUATA*).

Original Articles

SOME COMMON INDIAN BIRDS.

No. 30. THE ROSE-RINGED PAROQUET (*PSITTACULA TORQUATA*).

BY

T. BAINBRIGGE FLETCHER, R.N., F.L.S., F.E.S., F.Z.S.,
Imperial Entomologist ;

AND

C. M. INGLIS, M.B.O.U., F.E.S., F.Z.S.,
Curator, Natural History Museum, Darjiling.

THE great family of the Parrots is so widely distributed throughout the Tropical Regions of the World and is composed of so many different species that it is difficult to say why the Indian list of indigenous forms should be so scanty, only a dozen species, represented by nineteen sub-species, being known to occur. But perhaps it is well that we have no more ; for, as Dewar remarks, "the green parrot is one of those good things of which it is possible to have too much."

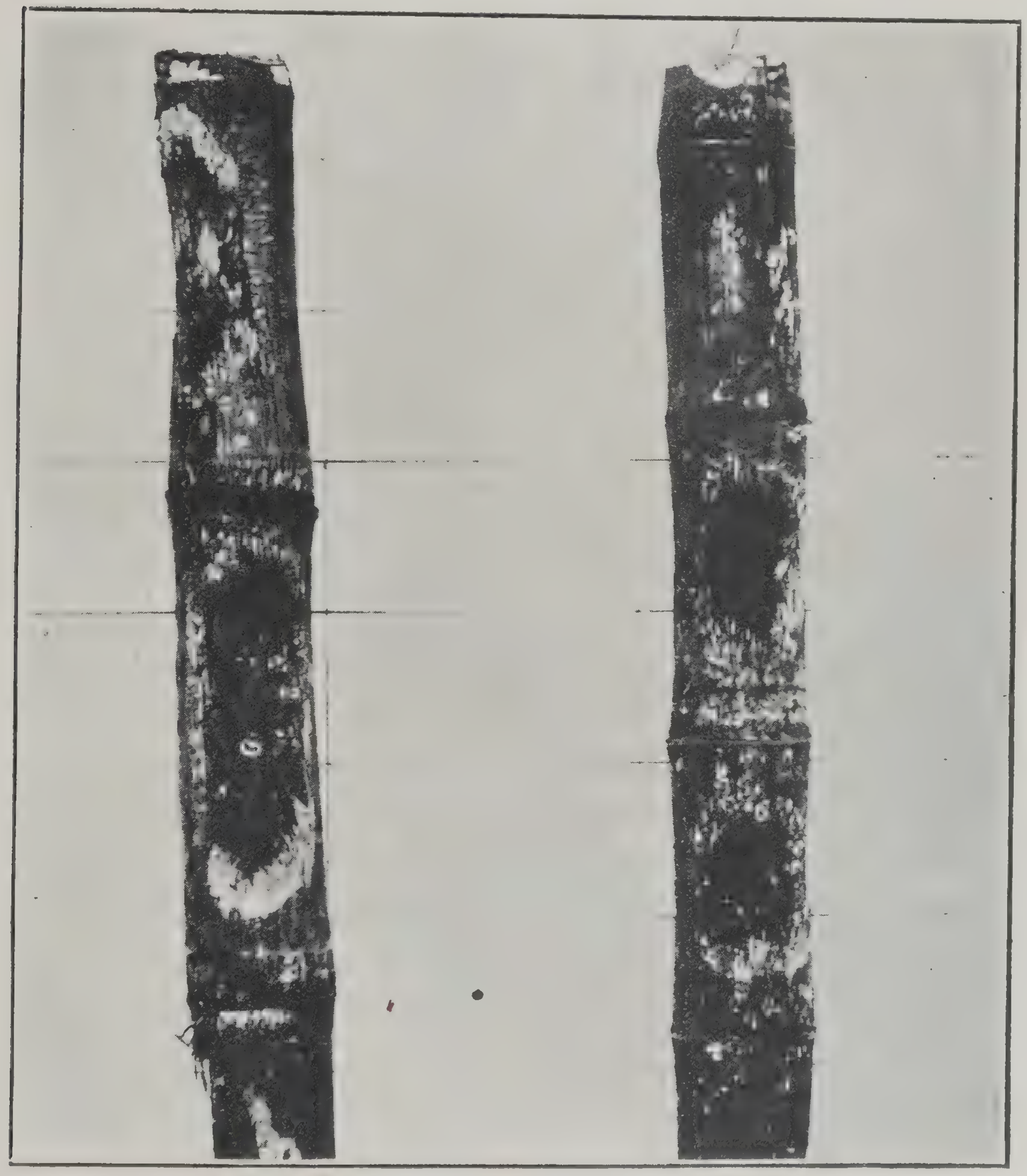
Parrots are sharply distinguished from all other classes of Birds by several anatomical peculiarities in their vertebræ, feet, and other parts, into which we need not enter here. Most Indian Parrots are easily recognizable as such, their most obvious characters being the short, stout, strongly-hooked bill, thick fleshy tongue, movable upper mandible, climbing habits, and (in most species)

long tail and greenish colour. The subject of our present article may be distinguished from all other Indian Parrots by its long tail, head (except chin and mandibular stripe in males) and body green, bill deep red, with no red patch on the wing-coverts. It is by far the commonest and most familiar of the green Indian Parrots, occurring abundantly in all open and cultivated land around towns and villages, often in large flocks, dashing over the tree-tops in swift, arrowlike flight. It is found practically everywhere throughout the Plains of India, Burma and Ceylon, but seems to be commoner in Northern India than in Madras.

Rose-ringed Paroquets attacking wild fruits.

Wherever it occurs, however, in its wild state the Rose-ringed Paroquet is an unmitigated nuisance, as its diet is wholly vegetarian and it feeds largely on cultivated grains and fruits. When a large flock descends on a ripening crop of *juar* (sorghum) or similar cereal,

a great deal of damage is done, some by the actual grain that is eaten, but far more by the extremely wasteful method of feeding of this bird, which often breaks off a whole head, delicately



Sugarcane damaged by parrots in Assam (From a photograph by Dr. C. A. Barber).

selects one or two grains, throws away the rest, and breaks off another head which is treated in the same way. When fruits are ripe, these birds soon find them out and play havoc with them.

When no cultivated fruits or crops are in season, the food consists of wild fruits (wild figs, *Zizyphus*, etc.) and seeds. The late Mr. C. W. Mason examined fifty-three birds at Pusa and Mr. D'Abreu three more at Nagpur, and in all cases the stomach-contents consisted entirely of vegetable matter--mustard, wheat, maize, paddy, litchi and wild fruits, and seeds of *Dalbergia sissu*. When the silk-cotton trees are in flower in February these parrots are amongst the crowd of birds which congregate to imbibe the nectar. We have not yet had any complaints of its attacking sugarcane but, with the increasing cultivation of this crop in Bihar, it will perhaps discover that it is edible and attack it in the same way as another Parrot has damaged sugarcane in Assam, by gnawing large holes in the stems.

The Rose-ringed Paroquet does not deserve, nor has it been afforded, any protection under the Wild Animals Protection Act: on the contrary, its destruction should be encouraged and, if this could be done by exempting the export of its plumage from the present Customs restrictions, or in any other way, it would be all to the benefit of the cultivator who is practically powerless at present to prevent the immense damage done to his crops by this destructive bird.

It must be admitted, however, that from a purely æsthetic and non-utilitarian view-point the Rose-ringed Paroquet is a decidedly handsome and attractive bird when seen under natural conditions flashing through the sunshine or climbing over a tree in search of food, and, in places where its numbers are but small, its brilliant hues, delicate outlines and dainty ways provide a perennial source of joy to the bird lover. But in country districts, where it is only too abundant, its destructive habits and shrill harsh screams very quickly nullify such feelings of admiration.

As a cage-bird the Rose-ringed Paroquet is a favourite all over India, and thousands of young birds must be taken every year from their nests and doomed to pass the remainder of their existence within prison bars, although unfortunately this annual toll seems to make little difference to the total numbers which exist to ravage the farmer's crops. As its powerful beak soon secures its escape

from a wooden cage, this bird is usually kept in a small dome-shaped cage made of hoop-iron, with a sheet-iron floor, which must get uncomfortably like an oven in the hot weather. With a little instruction, this parrot often becomes a good talker, and it can also be taught to perform tricks. Lockwood Kipling tells of one that he used to see in the streets of Delhi "that went through gymnastic and military exercises, whirling a tiny torch lighted at each end, loading and firing a small cannon, lying dead and coming to life again ; all done with a comic air of eagerness and enjoyment which it seemed hard to impute to mere hunger for the morsels that rewarded each trick."

The Rose-ringed Paroquet breeds in January and February in Southern India, from March to May further North. No regular nest is made but the eggs are laid in a branch of a tree, occasionally in a wall. If a suitable hole is already available, the birds appropriate it, and couples may often be seen, at Pusa about the end of February every year, inspecting eligible sites, which by that time are often occupied by Hoopoes. If no acceptable hole can be found, the birds may excavate one for themselves and Colonel Butler noted a pair at Deesa which were at work clearing out the hole, in which the eggs were subsequently deposited, for at least three months before the eggs were laid. A finished hole, either acquired or excavated either wholly or in part, is generally about two inches in diameter, and goes straight into the trunk for two to four inches and then turns downward for a distance of six inches to three feet, the lower portion being expanded into an egg-chamber which is four or five inches in diameter. Should a natural hollow in the tree be utilized or cut into, the chamber may be much larger. The entrance-hole is cut either into the trunk of a tree or into a large bough ; in the latter case it is often placed on the lower side of the bough. No lining is provided, the eggs being laid on a few chips of wood at the bottom of the hole. The usual number of eggs is four but as many as six are found at times. The egg is pure white, without any gloss, usually in shape a moderately broad oval, considerably pointed towards one end, and measures about 30 by 24 millimetres.

Our Plate shows both sexes of this Paroquet, the adult male being distinguishable by his rosy collar which is absent in the female.

Head of male Rose-ringed Paroquet.

DAIRY EDUCATION IN DENMARK.*

BY

N. KJAERGAARD JENSEN,
Professor in Dairying, Royal Veterinary and Agricultural High College, Copenhagen.

WHEN speaking about dairy education in Denmark, one must unavoidably divide it into two parts—first. the low (inferior or junior) education, whose object is to provide the dairy industry with dairy managers, practical dairymen, and second, the high (superior or senior) education, which prepares lecturers for dairy colleges, graduates in dairying, etc.

The low education can again be subdivided into practical and theoretical education.

The practical education has been for many years entirely free and planless. A dairy could keep as many apprentices as it chose to and at the same time the period of apprenticeship was not fixed, nor was it obligatory for the apprentice to learn or the instructor to teach butter and cheese-making as well as other dairy work in a specially stipulated period.

The planlessness of such education drew the attention of the dairy circles, and the Danish Dairymen's Association (Association of the Dairy Managers) decided to have this position improved. In 1910, the Board of the Association took the initiative into its own hands and worked out a scheme proposing a four years' period for apprenticeship. The scheme was accepted and approved, but at first it continued to be only voluntary whether the apprentice wished to learn under the supervision of the Association or not;

* Paper read at the World's Dairy Congress, 1923.

from 1918, however, the four years' apprenticeship became compulsory.

The rules for such education for the teacher are the following: Each member of the Danish Dairymen's Association undertakes to instruct an apprentice in all dairy work as thoroughly as possible and instruct him also in accountancy and recording of the dairying operations. The instructor is also obliged to have literature on dairy industry which is to be kept at apprentice's disposal.

The programme for apprenticeship stipulates the period of such to be four years. During the first year all kinds of dairy work are to be gone through. After that comes a year of learning butter-making, followed by another year for cheese-making and then the last year in which the apprentice learns some engineering—machinery, engines, heating, etc.

It is not necessary for the apprentice to go through the four years' work in the order mentioned above, but it is absolutely compulsory that a whole year is spent in learning each of the four subjects named. The apprenticeship must be done in at least two and not more than three different first class dairies. The last three years the apprentice must keep the dairy accounts as well as record all milk and products through all operations.

At the end of the fourth year the young dairyman receives a "certificate of apprenticeship" signed by the Board of the Association.

As already mentioned, before 1918 every dairy had the right to keep as many apprentices as it chose, but from that year it was agreed upon between all the dairy organizations that the number of apprentices at each dairy had to be limited to a certain point in proportion to experienced dairymen, so as to ensure that at any time given all dairies have a sufficient staff of experienced dairymen to conduct and supervise the work of the dairy.

The theoretic education began in 1889, when the now deceased President of the Ladelund Agricultural College, Mr. Niels Pederson, founded the College of Dairy Education by opening a five months' course for future dairymen for theoretic education solely. The programme of the course comprised chiefly: chemistry, physics,

treatment of domestic animals, machinery and instruction in dairying. This five months' course for dairymen was continued parallel with the agricultural course till 1910 when the Dairy Associations intervened owing to the rapid development of the dairy industry. They approached the two existing colleges with a suggestion that a more thorough system of education was required, and it was agreed to have the period of training extended to eight months, namely, from 1st September to the end of April. This arrangement was brought into effect in both colleges from 1st September, 1910, and has continued to the present day. It was also decided to put the system of education in both colleges on an equal footing and have the students examined on every subject once a year by a body of examiners representing both colleges. The students in these colleges are instructed in theoretical and practical chemistry and bacteriology, physics, treatment of domestic animals, machinery, commercial calculations, and accountancy; also attention is given to writing, arithmetic, drawing and gymnastics.

The working day in such a college is arranged as follows: lectures from 8 a.m. to noon with 10 minutes' recreation between each lecture; from noon to 2 p.m. is allowed for dinner and recreation, and the lectures are continued from 2 to 6 p.m. In the evening the students must read and prepare themselves for the next day. They are enrolled to attend at every lecture and should something prevent a student from doing so, an instructor or the director of the college has to be informed of the cause.

The advanced education.

Up to the year 1904 all students who desired to become lecturers or graduates in dairying received the same theoretical education as an agricultural student at the Royal Veterinary and Agricultural High College in Copenhagen. The syllabus comprised: chemistry, physics, geology, botany, zoology, anatomy, mensuration and levelling, drawing, mathematics, cultivation of plants, horse-breeding, treatment of domestic animals, dairying and agricultural book-keeping, general agriculture as well as agricultural chemistry. The normal course continued about twenty months and finished

with two examinations. The first examination covered general education and took place after about nine months' attendance; the second examination was devoted to the remaining subjects and was held at the end of the course.

On 1st September, 1904, a supplementary course for agricultural students wishing to graduate in dairying was founded. To attend this course it was obligatory for the student to possess sufficient knowledge of German and English to enable him to read books written in these languages.

Before being admitted to the examination following the last course, the student has to pass first the agricultural examination, as well as show evidence of high character. The period for this course is also twenty months and includes the following subjects: physiology, agricultural chemistry, pathology, treatment of domestic animals, bacteriology, country law, political economy, practical work in chemistry and bacteriology, and drawing. The course is followed by an examination.

But the Dairy Associations were not entirely satisfied with the arrangement that a dairy student was obliged to follow a training in agriculture before beginning his special studies in dairying. Necessary steps were undertaken by the Danish Co-operative Dairy Association to have the above arrangement altered. The Royal Veterinary and Agricultural High College in Copenhagen immediately declared itself willing to support the Association. The position was considered and new rules were issued to commence from 1st September, 1921.

The new course spreads itself over two to three years. However, before passing the examination the student must go through a practical education which is to be approved of by the Royal Veterinary and Agricultural High College. This practical work is expected to take at least four years after the student has reached the age of 15, or three years after he has attained his 17th year.

The period of education is divided into two parts; the first continues for eighteen months and the following subjects are studied: physics, meteorology, chemistry, geology, botany, microbiology,

laws of heredity, zoology, anatomy of domestic animals and physiology, political economy, agricultural chemistry, practical work in physics, chemistry and bacteriology, and drawing. The second part continues for about eighteen months, and deals with the treatment of animals, management of the dairying industry, dairy chemistry and bacteriology, also agricultural geography, general agriculture, pathology and practical work in machinery, house-building, general agriculture, agricultural chemistry, dairy chemistry and dairy bacteriology.

The first graduate in dairying educated under the new rules completed his studies on the 1st of May, 1924.

Before closing this short contribution it must be mentioned that also in the Copenhagen Polytechnicum, students studying to be factory engineers go through a course of dairying under the guidance of Professor Orla-Jensen, Ph.D.

THE CONTROL OF COTTON PESTS IN NORTH INDIA.*

BY

P. B. RICHARDS, A.R.C.S., F.E.S.,
Entomologist to Government, United Provinces.

It is unnecessary to labour the importance of the Indian cotton-growing industry, either to the welfare and wealth of India itself, or as a factor in world economics. Everyone knows how essential it is that cotton should be produced in India to satisfy the requirements of the mill and home spinning industries for clothing the millions of this country ; it is common knowledge to most of us that the world's markets are hungry for more cotton, and that world-wide efforts to find new fields of supply are being made ; and it may have been noted that a demand for Indian-grown cotton is arising in the English market. The increase in quantity and quality of the Indian cotton crop is thus of paramount importance to the producer, consumer, industrialist and economist alike.

Improved methods of cultivation, improved varieties, and increase of area are the more obvious means of increasing the supply ; but to those who have given no attention to the effect of insect attack upon the yield of cotton, it may be a surprise to hear that the control of insect pests would be equivalent to increasing the total area by 30 to 50 per cent. In other words, the soil already under cotton cultivation produces annually one-third to one-half more cotton than ever finds its way to the looms. Instead, it serves to feed a horde of insects.

The insects which attack the cotton plant are numerous and diverse. Among them are species of grasshoppers, white ants, bugs, beetles, butterflies, and moths ; they eat the roots, stems, leaves,

* Paper read at the Agricultural Section of the Indian Science Congress, Bangalore, 1924.

EARIAS INSULANA.

flowers, seed and lint, suck the sap, and abstract the contents of the seeds ; and they vary in size from minute bugs of a twentieth of an inch in length to ponderous beetles of an inch and a half. Fortunately all are not equally numerous and rapacious. The bulk of them may be regarded as of very minor importance, and so far as the North of India is concerned, the really bad offenders may be said to be two, both the larvæ of moths. These larvæ are commonly known as the Spotted Boll-worm and the Pink Boll-worm.

The Spotted Boll-worms (Plate XVII) are the caterpillars of three species of *Earias*,* a genus of the family Noctuidæ. The first Spotted Boll-worms appear in the cotton fields when the seedlings are young, and damage the plants by boring into the stem, thus killing the main shoot. Later they attack the flower-buds, flowers, and young bolls, completely eating out the contents of buds and bolls leaving the empty shells, and wandering over the plant in search of fresh supplies. Each individual thus destroys many potential bolls during the three weeks or so which it takes to reach the full-fed condition prior to pupating. At this time it is a fat, thick-set caterpillar of a dull grey colour, dotted all over the dorsal surface with irregular brown dots, [illegible] inch. It comes out of its last boll, spins a canoe-shaped cocoon of brown silk concealed among dead leaves or flowers, pupates, and within a fortnight the moth emerges. Descriptions of the adults may be found in Lefroy's "Indian Insect Life" or Fletcher's "South Indian Insects." They are nocturnal, and are not much attracted to light or other traps, so it is not possible to deal with them in the adult condition. The fertilized female lays very beautiful small blue eggs, singly, on the leaves and bracts of the cotton plant, from which emerge a new generation of caterpillars to continue the mischief.

The fecundity is considerable, and the rate of generation rapid. One female lays sixty to eighty eggs, and in four weeks or so a generation is complete. It thus seems that as the caterpillars

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* *Earias fabia*, Stoll ; *E. insulana*, Boisd. ; *E. cupreoviridis*, Wlk.

EXPLANATION OF PLATE XVII.

Earias insulana.

1. The boll-worm.
2. An attacked boll, showing the black mass of excreta thrown out
3. An attacked shoot, the worm being inside.
4. A moth with closed wings, as it rests on the plant.
5. Another view of the worm.
6, 8. The moths.
7. The moth of a similar but distinct species which does not attack cotton.

EARIAS INSULANA.

flowers, seed and lint, suck the sap, and abstract the contents of the seeds ; and they vary in size from minute bugs of a twentieth of an inch in length to ponderous beetles of an inch and a half. Fortunately all are not equally numerous and rapacious. The bulk of them may be regarded as of very minor importance, and so far as the North of India is concerned, the really bad offenders may be said to be two, both the larvæ of moths. These larvæ are commonly known as the Spotted Boll-worm and the Pink Boll-worm.

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can theoretically increase in powers of 30 every four weeks, and each caterpillar can destroy several small bolls or one or two large ones, there would not be sufficient bolls produced to satisfy the demands of the third or fourth generation. Fortunately Nature does not work in this way—the theoretical rate of increase is not maintained for any length of time unless under very exceptional conditions. Various natural controlling factors operate to check the rate of increase in normal seasons. A little further enquiry into the habits of the Spotted Boll-worm will show how some of these work.

The larva, when it emerges from the egg, is a minute creature about one-tenth of an inch long with a slender, bristly body. It will be remembered that the eggs are laid singly on the leaves and bracts. In most varieties of cotton the leaves are hairy. Many of the young caterpillars appear to obtain their first food from the tissues of the leaf on which they were hatched. Now, if the leaves are densely pubescent, this is a matter of difficulty, as the caterpillars are not easily able to reach the epidermis. The leaf tissue does not in any event satisfy the insect long. After a small feed it proceeds to seek a bud or boll into which it may burrow. Here again its progress is much hampered by the hairs of the leaf. A considerable number of the caterpillars thus fail to arrive at a bud or boll at all, especially in hot sun or during rain. The more successful individuals which do succeed in reaching a bud or boll eat their way into the centre of it, making a round entrance hole which remains open, and out of which may frequently be seen protruding a quantity of yellow or brown frass. During the early days of the insect's existence, it usually selects buds in preference to larger bolls. Having completely eaten up the contents of one, it comes out and wanders in search of further food.

Finally the caterpillars of the later generations tunnel their way into well-developed bolls, eat the seeds, sometimes of the whole boll but more frequently of one or two of the loculi, and fill the cavity with a mass of brownish excrement. The destruction of the seed, of course, involves the lint. It is probably in such larger bolls that the damage done is of greatest importance to yield and quality.

During its peregrinations the caterpillar is, of course, exposed to attack by insect-eating birds, and predaceous and parasitic insects. Moreover, the younger attacked bolls readily fall from the plant, and many caterpillars, especially during wind or heavy rain, fall to the ground within the bolls. If there be standing water in the field, most of such caterpillars are drowned. This often affords a very effective check, wiping out a considerable proportion of the pest.

An appreciable natural check is that of parasitic Hymenoptera, species of *Rhogas*, which lay eggs on the caterpillar from which emerge grubs which slowly consume its body. These parasites do not appear to be sufficient in themselves to keep the pest in check. So far as I know, no accurate determination of their effectiveness has been attempted, but it is estimated to be about 10 per cent. It is probable that, under optimum conditions, it will prove to be considerably higher in certain areas. It is, at the least, a useful helper in the good work.

There is another probable check of which at present we know very little. Many Spotted Boll-worms are often found dead within the bolls. This is especially the case after a period of damp weather, and it is inferred that fungi or bacteria are responsible. It should be remembered, in this connection, that the large hole made in the boll wall on entry remains open, and that water, fungus spores, and bacteria can thus readily enter the boll. There is here, perhaps, a fruitful field for investigation and experiment; but the artificial induction of an epidemic among healthy insects is a difficult and uncertain matter, involving expert technique and wide-spread spraying operations, and generally limited in effectiveness by the climatic factor.

As to the actual loss of crop resulting from Spotted Boll-worm attack, I have no figures of my own; nor do I know of any critical experimental data. In the United Provinces, so far as my experience goes, I do not estimate it at more than six or seven per cent.—say, an anna in the rupee—but that is practically a guess-work figure based on observations of attack of the larger bolls. It does not take into consideration, among other possible effects, the retarding

of growth due to the original attack on the shoots of seedlings, the loss of cotton from the young bolls, the flowers, and the buds which are frequently destroyed in considerable number, or the effect upon lint production in partly consumed bolls. It is hoped that data will be forthcoming shortly which may help to determine the absolute damage and the relative importance of this pest in the United Provinces. In 1917 the Imperial Entomologist stated that in the Punjab, in some years, the damage "is very serious indeed, running into a loss of several million pounds sterling."

There is one more fact in the life-history of the Spotted Boll-worm to which I must direct your attention. I have mentioned that the caterpillar comes out of the boll when full-fed and pupates in a tough, cryptic-coloured cocoon of silk. It is in this condition that the insect usually survives the winter, either in cracks in the soil or concealed among dead leaves or the like rubbish. Emerging as a moth in the spring, it is usually able to recommence breeding on other plants than cotton, notably *bhindi* (*Hibiscus esculentus*) and other species of *Hibiscus*, and on *Abutilon indicum*. None of the three species of *Earias* is confined to cotton.

A consideration of the foregoing shows that, so far as investigations have carried us, no universal panacea can be evolved for the Spotted Boll-worm. Spraying or dusting the plants with poisons is of doubtful effect, entails an outlay in materials and appliances which would deter the small cultivator, and is a method involving considerable risk when employed unintelligently. The presence of the pest in wild foodplants, and its liking for such a commonly grown vegetable as *bhindi*, militate against the effectiveness of methods involving compulsory destruction of cotton sticks or rubbish after harvest. The low percentage of parasite infection puts a limit to the value of breeding and distributing parasitic insects in the cotton tracts. Trap crops have been tried with poor success; while the evolution of immune races of cotton is a dream hardly likely of realization.

The reduction of the numbers of this pest, with the consequent saving to the country of some part of the crores of rupees now said to be lost annually, appears more likely to result from

PLATYEDRA (GELECHIA) GOSSYPIELLA.

application of simple methods capable of being grafted on the routine agricultural practice of the cultivators. The ground should certainly be cleared of ratoon plants, [illegible] and rubbish between seasons; the early attack on seedlings should be utilized as a trap for the first generation of the pest, either by uprooting attacked plants or by topping them below the bored part, and at once destroying the contained insects; while at each irrigation or during each heavy fall of rain the plants should be shaken to ensure the majority of attacked bolls falling off into the water, so drowning the contained caterpillars. Further good may possibly result from the selection of densely hairy varieties of cotton.

It was at first [illegible] responsible for most of the damage to bolls throughout North India. Investigation has, however, shown that the Pink Boll-worm is a much more pernicious and dangerous pest. This has for long been recognized in the United Provinces, and, whether because of the spread of the pest, or through more extended observation, [illegible]

The Pink Boll-worm [illegible] moth, *Platyedra gossypiella*, Saund. The moth is an insignificant, brown insect, four-tenths of an inch long, nocturnal, and has the habit of scuttling under shelter if disturbed by day. Although inconceivable numbers of the moths are produced every year, very few even of the folk concerned with cotton have seen the adult insect, at any rate to recognize it as the imago of the Pink Boll-worm.

In order to indicate the nature of the damage and the problems to be faced in reducing it, I must describe, as briefly as possible, the course of events throughout the twelve months from one cotton sowing to the next. I will start from the arrival of the adult moths in the cotton fields. We will see later how they get there.

The appearance of the moths follows the planting by a period of three to four weeks, dependent, apparently, upon the humidity of atmosphere and soil. Egg-laying commences coincident with the development of buds and flowers. The eggs are minute ovals, barely visible to the eye, but shown by a lens to be delicate,

EXPLANATION OF PLATE XVIII.

Platyedra gossypiella

1. Eggs—green when laid, brownish before hatching.
2. Newly hatched larva.
3. Full-grown larva.
4. Pupa
5. An affected boll which is open, showing the larva and pupa in the lint and also a seed in which there is a hibernating larva.
6. The same seed cut open to show the hibernating larva.
7. Moth in resting attitude.
8. Moth with wings expanded.

PLATYEDRA (GELECHIA) GOSSYPIELLA.

application of simple methods capable of being grafted on the routine agricultural practice of the cultivators. The ground should certainly be cleared of ratoon plants, cotton sticks and rubbish between seasons; the early attack on seedlings should be utilized as a trap for the first generation of the pest, either by uprooting attacked plants or by topping them below the bored part, and at once destroying the contained insects; while at each irrigation or during each heavy fall of rain the plants should be shaken to ensure the majority of attacked bolls falling off into the water, so drowning the contained caterpillars. Further good may possibly result from the selection of densely hairy varieties of cotton.

It was at first believed that the Spotted Boll-worm was responsible for most of the damage to bolls throughout North India. Investigation has, however, shown that the Pink Boll-worm is a much more pernicious and dangerous pest. This fact has long been recognized in the United Provinces, and, whether because of the spread of the pest, or through more extended observation, it is also being realized in other provinces.

The Pink Boll-worm (Plate XVIII) is the larva of a Gelechiad moth, *Platyedra gossypiella*, Saund. The moth is a small, insignificant, brown insect, four-tenths of an inch long, nocturnal, and has the habit of scuttling under shelter if disturbed by day. Although inconceivable numbers of the moths are produced every year, very few even of the folk concerned with cotton have seen the adult insect, at any rate to recognize it as the imago of the Pink Boll-worm.

In order to indicate the nature of the damage and the problems to be faced in reducing it, I must describe, as briefly as possible, the course of events throughout the twelve months from one cotton sowing to the next. I will start from the arrival of the adult moths in the cotton fields. We will see later how they get there.

The appearance of the moths follows the planting by a period of three to four weeks, dependent, apparently, upon the humidity of atmosphere and soil. Egg-laying commences coincident with the development of buds and flowers. The eggs are minute ovals, barely visible to the eye, but shown by a lens to be delicate,

net-marked, iridescent-shelled objects about half a millimetre long. Two to four hundred eggs may be laid by one female, and they are laid singly among the hairs of the bracts and stems of flowers or bolls, on the stems of the young shoots, and on the axils, petioles, and laminæ of the younger leaves. From the egg, from three to ten days after laying, emerges a white larva about one-twelfth of an inch long, with small dark head and slender flexible body. It immediately seeks a bud, flower, or boll, and proceeds to eat its way inside. In bud or flower the anthers are first attacked, but the insect may finally enter the ovary. A young bud does not afford sufficient food for the development of the larva, nor does a very young boll. From these, when consumed, an excursion has to be made in search of fresh supplies. But a single flower or an older boll provides all the necessary nourishment, and once entered is not left until the caterpillar requires to pupate. Hence, unlike the Spotted Boll-worm, the Pink Boll-worm is seldom required to leave its shelter, and is very rarely to be seen at large on the cotton plant. This is wisdom, because in the course of a few days' rich feeding, it loses its delicate appearance and becomes a stout, conspicuously pink caterpillar, which would surely prove a tempting titbit to birds, and a promising and unprotected field for the egg-laying operations of parasitic insects. But, further than this, it has learnt how to enter a cotton boll without leaving an open, tell-tale hole through which fungi, bacteria, and parasitic insects may follow to its detriment. The bore hole of the Spotted Boll-worm remains open. That made by the Pink Boll-worm very rapidly closes over, leaving practically no scar or trace by which insect, bird, or man may discover the caterpillar's presence. Its ingenuity in self-preservation extends further. The Pink Boll-worm, like its Spotted associate, eats the developing seed in the boll, but it does this in such manner that the plant is not much disturbed, and the attacked bolls are seldom loosened. Thus when a storm of wind and rain causes havoc among the Spotted population, the Pink community ride out the tempest snug and secure in their sealed and firm-fastened chambers. Nor is even this the full extent of its cunning in concealment and self-preservation. It has evolved

a means whereby it ensures its safety throughout the cold and hot seasons, and by which, at the break of the rains, the cultivator whose crop its offspring will ravish is made the unwitting agent of his own ill. In its last expression the Boll-worm's cunning may perhaps have overshot the mark, to its ultimate undoing. But I must not anticipate. These matters belong to a later chapter of the story.

To follow further this first generation of larvæ; the feeding stage occupies about twelve to fifteen days, the pink colour appearing about half way through this. The full-fed larva pupates inside a thin silken cocoon within the hollowed seed, or among the lint, the bracts, or withered leaves, or sometimes attached to the stem or in cracks in the soil. Ten days to a fortnight later the adult moth emerges, and egg-laying recommences.

A complete generation, in which the insects may increase one hundred to two hundred fold, thus occupies from twenty-five to thirty days in the monsoon. Four such generations between July and October frequently result in the production of so many Pink Boll-worms that ultimately practically every boll harbours one or more.

Towards the end of October, when the temperature begins to fall and the air to dry, a marked change of habit is noticeable in most of the larvæ. When they are full-fed, all but a few, instead of pupating at once, spin themselves snug cradles of silk inside a hollowed seed. If the seeds are small, two or more may be securely fastened together for this purpose. Within these the larvæ sleep out the cold weather and the heat, awaking to activity again only after the onset of the monsoon.

The few exceptions pupate, and moths emerge which lay eggs on such cotton plants as may be available. The development of the resulting larvæ in the cold weather is slow, but under favourable conditions two generations may be passed through during the winter; while, if the cotton is left in the ground through the hot weather, two more generations may ensue in such flowers as are produced. The numbers are, naturally, limited by scarcity of food, but they may prove important in attempts at control.

Such generations as do not hibernate we designate "short-cycle," while the larvæ which spin up for the winter we call "long-cycle."

Most of the long-cycle larvæ pass through the ginning process uninjured, and remain dormant until, at the next sowing time, they are sown in the fields along with the sound seed. As soon as the humidity is sufficient they come out of their silk-lined chambers, work their way to the surface by constructing a silk-lined tunnel, pupate within the tunnel, and ultimately, in the course of a few days, emerge from it to await the opportunity afforded by buds and flowers for the all-important purpose of ensuring the continuance of their race, with the incidental cost to the cultivators of a few crores of rupees.

The actual nature of the main damage done by the individual is that buds, flowers, and young bolls are completely destroyed; that in the older bolls a few to all the seeds in one lock are eaten out, so that either useless lint, or none, is produced; that one caterpillar may destroy some of the seeds in more than one lock, consequently damaging more lint; and that the quality of lint, oil-content, and germination power of unattacked seeds in the boll are often adversely affected.

In the United Provinces the cultivators' estimates of the loss from the Pink Boll-worm is two to eight or more annas according to locality and season. As ten annas is said to be a good average crop, this would mean approximately fifteen to a hundred or more per cent. over the harvested crop. My own experiments this year substantiate the enormous amount of damage done. I consider that an average loss of 25 per cent. is a conservative estimate. Now, the United Provinces, which is by no means the largest cotton-growing area affected by the Pink Boll-worm, is estimated to produce about eighty million pounds of cotton. This means that over twenty-five million pounds which ought to come to maturity fail to reach the market. These are, of course, round figures, still requiring definite proof; but add to them the damage caused in the Punjab and other cotton-growing areas in North India. Then, even if this is a considerable over-estimate of the loss, the total will

still be a colossal figure, and it will be appreciated that any measures which will effect the saving of all or most of the crop now lost will add materially to the wealth and well-being of the country. The problem is, how this is to be accomplished. It is obvious that none of the measures suggested for the Spotted Boll-worm will apply, excepting the clearing up of fields between seasons. The effective concealment practised by the larva and the moth precludes hand-picking operations, and renders poisoning ineffective. The adults are only slightly attracted to light-traps, nor do parasitic insects give us any reason to expect much help from them. Parasites of *Platyedra gossypiella* are scarce in India, and, as the insect is probably indigenous, there is not much likelihood of finding any effective ones elsewhere to import. Operations during the cotton season, thus, do not offer much hope. Where, then, is hope to be found ?

I suggested earlier that the insect had perhaps carried its cleverness too far. When it adopted the habit of shutting itself up for the off-season inside the hollow shells which, but for its mischievous activity, would have furnished food for beast and clothing for man, it may, perhaps, have delivered itself into the hand of the avenger. There, in the mass of seed, is the bulk of the next season's potential pest, and by suitable means of treating the seed, all the hibernating host can be destroyed.

This is the obvious solution. It has been seized in other countries to which the Pink Boll-worm has penetrated from India. It may prove to be the, and the only, solution of the problem for India. It is, however, a matter entailing vast outlay and organization, and the scheme for putting it into operation is not one lightly to be put forward. It must be backed by incontestable experimental evidence, and proof of its absolute efficiency, before its acceptance is conceivable or even desirable.

We know that by heating the seed to a certain temperature the larvæ can be killed without injuring the seed. There may perhaps be other and better methods, but this has proved effective, and capable of being carried out in ginneries. But to be of much use, the treatment should be universal. This means that all cotton seed

throughout North India would have to be dealt with—a formidable, but by no means hopeless proposition. But before such can be attempted there is much experiment to be carried out, and much definite knowledge to be sought. The causes which may affect the success of the method must be explored, such as the quantity and effect of hibernating larvæ in bolls dropped in the fields and the carry-over of short-cycle and long-cycle larvæ on alternative food-plants ; the actual value of the damage done by the Pink Boll-worm, and the additional return from pest-free crops must be determined ; and the feasibility of any method proposed for dealing with the infected seed must be clearly demonstrated.

An examination of these and other aspects of the problem is being conducted in Cawnpore by the Entomological Staff of the Agricultural Department of the United Provinces, with the co-operation of the Indian Central Cotton Committee. It is hoped that the investigation will result in means of controlling Boll-worm attack in North India, so ensuring to the cultivator the fruits of his labour, and to the country an increase in output and wealth, while calling, on the one hand, for no added toil, save that involved in the happy task of harvesting a full crop, and on the other, for no corresponding increase in area devoted to the crop.

It must, however, be remembered that scientific work frequently produces negative results, valuable from an academic view-point, but disappointing to the economic worker whose main interest is, of necessity, in attaining results of practical application.

The outcome of the enquiry is in the lap of the morrow. It is yet too early to offer any forecast of its results. There is much to be done before we shall know whether our hope will be realized ; but the indications at present are such as to warrant very considerable hope of satisfactory and practical results.

A PRELIMINARY NOTE TO THE STUDY OF FIXATION OF AMMONIA IN SOUTH INDIAN SOILS.*

BY

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In their preliminary note[1] on the decomposition of calcium cyanamide in South Indian soils, Norris, Viswanath and Ramaswami Ayyar have observed that the decomposition of cyanamide in the soil is very rapid up to the urea and ammonia stages, the oxidation of ammonia to nitrates proceeding more slowly. Since nitrification proceeds at this slow rate, there is little danger of all the nitrogen becoming available too quickly, before it can be utilized by the crop. In the case of paddy soils, however, the conversion of the cyanamide nitrogen into ammoniacal nitrogen is very rapid, and it has not been possible to say exactly how the ammoniacal nitrogen is assimilated by the plant.

As a preliminary step to study this problem, particularly in the absence of information as to the form in which ammonia is liberated, it has been found necessary to study the capacity of the soil to fix ammonia from solutions of its various salts. Three lots of 100 grm. each of paddy soil from the Central Farm, Coimbatore, were shaken for one minute and allowed to stand for one hour with 250 c.c. each of solutions containing 19·88, 26·24 and 37·0 mg. of ammoniacal nitrogen in the form of ammonium hydroxide, carbonate and sulphate respectively. At the end of one hour these were filtered and ammonia was determined in the

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* Paper read at the Agricultural Section, Indian Science Congress, Bangalore, 1924.

[1] *Mem. Dept. Agri. Ind., Chem. Ser.*, Vol. VII, No. 3.

aliquots of the filtrate with the following results, as tabulated in Table I.

TABLE I.

Showing the amount of nitrogen fixed by 100 *grm. of paddy soil from solutions of ammonium hydroxide, carbonate and sulphate.*

Solutions	Amount of nitrogen added	Amount of nitrogen recovered	Amount of nitrogen fixed	Percentage of nitrogen fixed on the added amount
	mg.	mg.	mg.	
Ammonium hydroxide ..	19·88	0·84	19·04	95·8
Ammonium carbonate ..	26·24	2·80	23·44	89·1
Ammonium sulphate	37·00	6·91	30·09	81·4

This preliminary experiment shows that the soil experimented with here is capable of fixing ammonia in any of the three forms given, and that the amount fixed is many times more than what will be available under any conditions of agricultural practice. The next point for investigation is the mechanism and range of fixation.

The problem of fixation by soils has received considerable attention for some time and quite a large volume of literature has developed on the subject. But the amount of work done in this direction on swamp soils is very meagre, if not practically nothing. The problem of ammonification and fixation of ammonia with special reference to paddy soils has, therefore, been taken up for study and the aspect of fixation is being considered first.

It has been held that the extent of fixation by soils is related to their agricultural value and that the greater the capacity of the soil to fix, the better it is suited for agricultural purposes. It has also been known that the process of fixation is generally, if not invariably, attended with base exchange, so that, while certain plant foods are held in a state of absorption by the soil for subsequent use, certain others are disengaged from the soil and made available

for the plant. In view of the importance of changes that take place when fertilizer salts are added to a soil, as in ordinary agricultural practices, and in view of the different types of soils existing in this presidency, this investigation has been extended to the different classes of soils and the results presented herein are some of the preliminary observations of the behaviour of ammonium sulphate on these different classes of soils.

It is realized that, from a chemical point of view, the manuring of a soil is an independent individual proposition, requiring a careful study of individual conditions. There is likely to be variation in the behaviour of a fertilizer with the different classes of soils and with different soils of a similar class. Such instances are not wanting in the vast mass of literature that has accumulated on the subject. However, there can be no denying the fact that the knowledge obtained from the behaviour of a particular class of salts towards specific types of soils cannot fail to be of a reliable guide in judging, in a general way, the manurial requirements of soils of a given type, particularly in a country like this where experimental work on soils is not far advanced.

Based on agricultural practices and natural conditions, the soils of this presidency can be divided into four main classes. They are (1) paddy soils, (2) garden soils, (3) black soils and (4) estate soils (planting districts).

(1) Paddy soils are essentially rice soils and the cultivation and cropping is always under submerged conditions.

(2) Garden soils are usually red soils under irrigation.

(3) Black soils are dry soils, dark in colour, containing proportionately larger amounts of lime and depending principally on rain.

(4) Estate soils are laterite soils from highlands with a heavy rainfall, are usually lighter than the other types and are characterized by their high content of iron and alumina and organic matter and very low lime content.

These four principal types of soils have been experimented with, and the pH values and the chemical and mechanical analyses of these four soils are given below in Table II.

Table II.

Chemical analysis.

Constituents	Paddy soil	Garden soil	Black soil	Estate soil
	%	%	%	%
Insoluble mineral matter	75·01	79·04	78·50	52·96
Iron oxide (Fe_2O_3)	5·39	4·73	3·06	29·73
Alumina (Al_2O_3)	10·16	6·68	7·06	
Lime (CaO)	1·01	1·50	3·67	0·06
Magnesia (MgO)	1·47	0·92	1·49	0·12
Potash (K_2O)	0·50	0·53	0·39	0·34
Soda (Na_2O)	..	0·12	0·18	..
Carbonic acid (CO_2)	..	0·54	1·30	..
Phosphoric acid (P_2O_5)	0·07	0·115	0·05	0·12
Sulphuric acid (SO_3)	..	0·03	Trace	0·42
Loss on ignition	5·14	5·79	4·30	16·01
Containing :—				
Nitrogen (N)	0·045	0·057	0·034	0·240
Available P_2O_5	0·011	0·036	0·015	0·0075
Available K_2O	0·010	0·018	0·003	0·013

Mechanical analysis.

Fine gravel	3·55	6·30	9·50	..
Coarse sand	20·09	17·40	25·00	26·35
Fine sand	27·77	19·10	15·10	14·38
Silt	11·52	6·50	6·40	14·49
Fine silt	26·04	21·10	28·10	17·97
Clay	7·26	25·70	12·00	6·92
pH values	8·50	8·1–8·3	8·3–8·5	7·0

The paddy, garden and black soils were obtained from the Central Farm, Coimbatore, and the estate soil is a composite of eight

soils received from Nallatanni Estate, Munar, Periakulam, for analysis, in the laboratory of the Government Agricultural Chemist, Coimbatore. All these soils were dried in air and passed through 1 mm. sieve.

100 grm. of soil were shaken with 250 c.c. of ammonium sulphate solution in a shaking bottle for a minute and allowed to remain for some time until equilibrium was established. At the end of this period the liquid was filtered through dry filter paper and the necessary determinations made. The determinations of the basic and acidic radicals were made by the usual methods obtaining in an agricultural laboratory, but a word has to be said about the determination of ammonia. There has been a large number of methods for the determination of ammonia in soils. The suitability of the various methods for our kind of work on ammonification is being investigated. It is felt that a critical consideration of these methods is necessary, where the soil *in situ* is used in experiments dealing with ammonification, but for the kind of work which is the subject matter of this paper the usual method has been considered sufficient. Accordingly the ammonia in the filtrate was determined by distilling it with 1 per cent. potassium hydroxide solution. All the figures given in the several tables here are the averages of two or more determinations.

The scope of enquiry is, for the present, limited to the following considerations—

(1) Time factor for attaining equilibrium between the fixer and the fixed.

(2) The influence of concentration on fixation.

(3) The nature of fixation.

The time required for the attainment of equilibrium between 100 grm. of soil and 250 c.c. of ammonium sulphate solution containing 37 mg. of ammoniacal nitrogen, ranging between one minute and four hours, was first determined and the results are tabulated in Table III.

TABLE III.

Showing the amount of ammonia fixed during varying periods of fixation. Nitrogen added 37 mg.

Soil type	Immediate N fixed	15 minutes N fixed	30 minutes N fixed	One hour N fixed	Four hours N fixed
	mg.	mg.	mg.	mg.	mg.
Paddy	30·49	30·05	30·19	30·09	30·98
Garden	33·36	32·34	32·19	33·08	32·43
Black	31·26	31·96	32·24	32·10	31·54
Estate	13·85	12·78	15·16	13·90	14·27

It will be observed that all the ammonia added is not recovered and that the soils are able to fix all the ammonia they could at that concentration almost immediately, and any increase in the time factor does not result in increased fixation at that concentration. In all the soils except the estate soil, the amount of ammonia fixed is nearly the same. In the case of estate soil, however, the fixation is low and is nearly half that of the other soils. The lighter texture of the soil may account for this behaviour.

TABLE IV.

Showing the influence of concentration of the added ammonium salt on the extent of fixation. Period of fixation one hour.

Concentration of the ammonium sulphate solution in terms of N added	PADDY SOIL 100 GRM.		GARDEN SOIL 100 GRM.		BLACK SOIL 100 GRM.		ESTATE SOIL 100 GRM.	
	N fixed	% fixed	N fixed	% fixed	N fixed	% fixed	N fixed	% fixed
mg.	mg.		mg.		mg.		mg.	
37 ..	30·09	81·4	33·08	89·4	32·10	86·8	13·90	37·60
111 ..	75·02	67·6	87·16	78·5	82·16	74·0	24·20	21·80
222 ..	125·40	56·5	152·00	68·0	141·64	63·8	47·28	21·30
555 ..	238·25	42·9	308·95	55·7	294·25	53·0	109·10	19·70

From the above table it will be seen that, while the absolute amount of ammonia fixed increases with increase in concentration of the solution of ammonium sulphate, the percentage fixation on the added ammonia decreases. This increase in the absolute amount, or decrease in the percentage fixed, is not, however, in direct proportion to the increase in concentration. Nevertheless, a certain amount of uniformity is observed in the case of all soils in the amount fixed. For instance, when the concentration is trebled all the soils absorbed about two and a half times the original amount. Similarly when the concentration is increased fifteen times all the soils absorbed 8 to $9\frac{1}{2}$ times the original amount.

As in the previous case, the fixation by estate soil is lower than that by the other soils and reaches the percentage constant earlier, i.e., at lower concentrations. If the percentages of ammonia fixed at various concentrations by the soils are plotted, the curve for the estate soil becomes almost a straight line even as early as at a concentration of 111 mg., whereas in the case of the other three soils it is not so.

From these two sets of experiments it will be seen that the soils may be said to fix ammonia in the following order:—Garden soil, Black soil, Paddy soil, Estate soil.

The results set out in Tables V and VI explain the nature of fixation. The liberation of bases is in proportion to the amount of ammonia fixed. This indicates that the process of fixation is essentially a chemical one. In all these experiments the chlorine and carbonic acid contents of the soils were not affected.

TABLE V.

Showing the equivalents of the different cations displaced.

100 *grm. of soil* plus 250 *c.c. ammonium sulphate solution* (37 *mg. N*).

NH_4 *added* 47·57 *mg.* SO_3 *added* 105·7 *mg.*

Soil type	Time of fixation—Immediate							Time of fixation—One hour						
	NH_4 fixed	Ca found in solution	Mg found in solution	K found in solution	Na calculated from balance of SO_3	SO_3 found in solution	NH_4 equivalent of Ca, Mg, K & Na	NH_4 fixed	Ca found in solution	Mg found in solution	K found in solution	Na calculated from balance of SO_3	SO_3 found in solution	NH_4 equivalent of Ca, Mg, K & Na
	mg.	mg.	mg.	mg.	mg.	mg.	mg.	mg.	mg.	mg.	mg.	mg.	mg.	mg.
Paddy ..	39·2	15·0	3·7	..	25·1	104·6	39·1	38·7	18·9	4·2	..	18·8	103·3	38·0
Garden ..	42·9	7·1	2·8	..	37·5	99·2 ?	39·9 ?	42·5	10·0	3·8	..	35·8	106·7	42·5
Black ..	40·2	17·9	3·0	..	25·4	106·3	40·5	41·3	19·6	3·9	..	21·9	104·3	40·7
Estate ..	17·9	7·1	0·5	..	1·1	85·4	7·0	17·9	8·0	0·5	2·1	..	82·0	9·0

TABLE VI.

Showing the equivalents of the different cations displaced.
NH_4 added 713·57 *mg.* *SO_3 added* 1585·5 *mg.*
Time of fixation one hour.

Soil type	NH_4 fixed	Ca found in solution	Mg found in solution	K found in solution	Na calculated from balance of SO_3	SO_3 found in solution	NH_4 equivalent of Ca, Mg, K & Na
	mg.	mg.	mg.	mg.	mg.	mg.	mg.
Paddy	306·3	155·7	43·7	8·8	120·4	1579·7	303·8
Garden	397·3	189·3	59·3	17·8	160·8	1579·4	393·6
Black	378·3	247·0	40·1	..	117·9	1577·8	374·8
Estate	140·3	35·1	5·4	5·3	64·2	1479·2	89·3

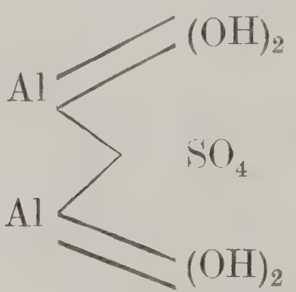
The balance of sulphuric acid (SO_3), after combining with NH_4, Ca, Mg and K, found in solution, is put down to soda on the analogy of combination of acids and bases in water analysis. It will be seen that the ammonium equivalent of Ca, Mg, K and Na equals the amount of ammonium fixed in the case of paddy, garden and black soils. In the case of the estate soil, however, a deficiency occurs and from Table VI it will be observed that 51 mg. of NH_4 and 106 mg. of SO_3 have to be accounted for. Experiments with iron alum and sodium sulphate have also shown that the sulphuric acid from these salts is held back by the estate soil. Similar results were obtained with phosphates also.

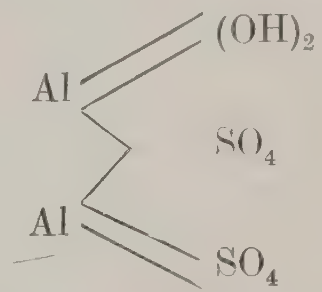
It may be that a portion of the ammonium radical equivalent to the SO_3 available is held up as ammonium sulphate by the soil or that the ammonium and the sulphate radicals are entirely in separate combinations. The latter view seems more probable from a knowledge of the agricultural behaviour of the estate soils.

The pH value of the estate soil indicates neutrality or at best a slight tendency towards acidity, and it is surprising that a soil with

a tendency to be acidic shows selective absorption (adsorption ?) towards acid ions.

It will be seen from the table of analysis (Table II) that this soil is very poor in lime and available phosphoric acid with a high content of iron and alumina and organic matter. It is probable that on the addition of ammonium sulphate to the soil, the acid radical, in the absence of lime, combines with the hydrosols of iron and alumina to form insoluble basic sulphates of the types





or double sulphates which are comparatively less soluble. Similarly when a phosphate is added the phosphate ion combines to form the insoluble phosphates of iron and alumina.

From a practical point of view, the indications of the evidence before us are that it is not advisable to apply a soluble phosphate like superphosphate before the application of lime to the soil, as in that case the phosphoric acid is all in combination with iron and alumina which may not be so quickly and easily available to the plant, even if lime is subsequently added. In fact, laboratory experiments have shown that liming did not disengage, in appreciable amounts, the phosphoric acid absorbed. Even if the phosphoric acid combined with aluminium is made subsequently available for the plant, there is always the risk of the hydrosols of these metals inducing a state of pseudo-acidity exerting their undesraible influences on the soil and on the plant. If, on the other hand, liming precedes the application of a phosphatic manure, the aluminium hydrosols are suppressed and the phosphoric acid can then go into combination with lime in which form the phosphoric acid is made more easily available to the plant. The evidence also points out that soluble phosphates like superphosphates applied alone may not be as effective as basic phosphates of lime.

Conclusions.

1. The soils of the Central Farm, Coimbatore, for instance, the paddy, garden and black soils, have a high absorptive power. The estate soil has a very low absorptive power.

2. The process of absorption is almost instantaneous.

3. The absolute amounts fixed by these soils increase with the increase in concentrations of ammoniacal solution used, while the percentage fixed on the added amount decreases and tends to reach a limit. In the case of the estate soil this limit has already been reached even at lower concentrations.

4. Consequent on the fixation there is a displacement of other cations from the soils. The chlorine and carbonic acid contents are not affected.

5. In the case of the estate soils all the anions (SO_3) added could not be recovered.

6. The NH_4 equivalents of Ca, Mg and K found in solution after treatment with the soil do not agree with the NH_4 fixed by the soil, but the difference so observed always equals the NH_4 equivalent of the balance of SO_3 found in solution, after combining with Ca, Mg and K.

7. When calculated to Na, as is done in this work, the sum of the several sulphates found in solution agrees closely with the total solids estimated.

8. When a higher concentration of ammonium sulphate solution is used, potassium is displaced in the soil.

9. The abnormal behaviour of the estate soil when compared with the other soils in holding back large amounts of acid radicals appears to be connected with the large amounts of iron and alumina and low amounts of lime present in the soil.

Before closing I must express myt hanks to M.R.Ry. B. Viswanath Garu, F.I.C., Offg. Government Agricultural Chemist, Coimbatore, for the very kind help, advice and encouragement accorded to me throughout this investigation.

SEASONAL VARIATION IN PADDY.

BY

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WITH THE ASSISTANCE OF

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AND

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Assistants.

The experiments concerned in this paper are the results of the study of seasonal variation in paddy plants with special reference to their flowering, tillering, length of straw and yield of crop for three consecutive years from 1920 to 1922.

As it is often desirable to express the degree of variability in exact mathematical terms, the writers have drawn a number of biometrical curves for three years separately of which each curve shows the seasonal variation among the individuals in the two particular classes of paddy, viz., the Sail and Broadcast Aus. The results have been calculated from a set of average variables in each individual group.

The experiments were carried on in $10' \times 10'$ plots where each variety was observed in regard to their respective flowering, tillering, length of straw and yield. 162 varieties of Sail and 56 varieties of Aus were taken for experiment on average. The season of sowing the seed-bed in the case of Aus comes in April and May, while that of Sail in June and July according to the favourable rainfall. The

rainy season extends from March to October with an average precipitation of 135″ per year at the Karimganj Farm, as is shown in the curves of Fig. 5. It may be mentioned here that the paddy farm at Karimganj, where the experiments were tried, is situated in an inundated area which is a typical Surma Valley paddy land of clay soil.

There is some relation between the yield and the flowering, tillering and length of straw of paddy. How much relation there exists between them will be pointed out later in detail from the tables and curves.

Variation in flowering.

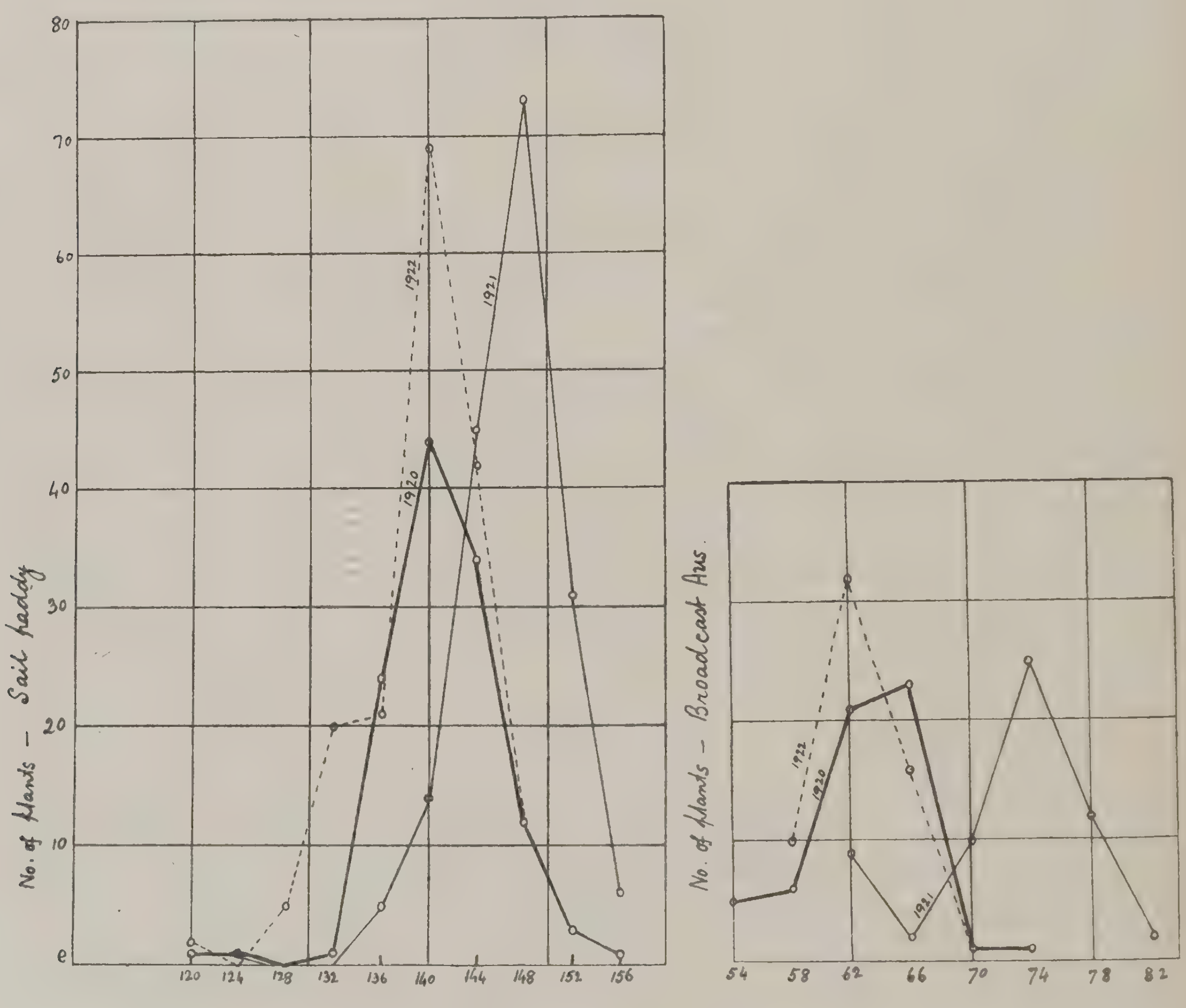
The Sail varieties flower every year at a particular time between the months of October and November irrespective of their date of sowing. This system of flowering in Sail may be taken as timely fixed. It is for this reason that the number of days from sowing to flowering in Sail directly varies with the date of sowing as the time of flowering is almost fixed. For example, a variety sown either on the 1st June or on the 1st July will approximately flower at the same time from the 15th to the 20th October.

Table I.

Showing the mode, mean and coefficient of variability and percentages of error in flowering of Sail and Aus paddies.

	Year	No. of varieties	Mode	Mean	Coefficient of variability in percentage
1. Flowering of Sail ..	1920	121	140	141·2	3·5 (± 0·15)
	1921	175	148	146·8	3·06 (± 0·11)
	1922	171	140	139·5	3·7 (± 0·13)
2. Flowering of Aus ..	1920	57	66	62·8	6·5 (± 0·41)
	1921	60	74	72·3	7·4 (± 0·45)
	1922	59	62	63·2	4·5 (± 0·28)

It may be pointed out here that in Table I there is some variation in the mean of the flowering in Sail, viz., 141·2, 146·8 and 139·5 in 1920, 1921, 1922 respectively. This is due to the fact that sowing was earliest in 1921 and latest in 1922. The difference in the number of days of the three means quite agrees with the difference in the number of days in the sowing time of the three years.



Number of days from sowing to flowering.

FIG. 1. Curves showing the number of days from sowing to flowering in Sail and Aus paddies for the years 1920–1922.

On the other hand, the time of flowering for Aus is rather periodic, i.e., they will flower in a definite length of time more or less irrespective of their date of sowing. This system of flowering in Aus may be taken as periodically fixed. The number of days from sowing to flowering does not vary with the date of sowing

but it may vary with the climatic condition. For instance, a variety sown in April or May will necessarily flower after a period of two months or so under normal conditions. But it may flower early owing to drought or late in case heavy rains and floods intervene.

Table I and the curves in Fig. 1 show clearly the variation in mode, mean, coefficient of variability and the calculated percentages of error in the experiment. In 1921 it is noted that the mean in Aus is 72·3, which is much greater than those of other two years. This excess of variation in the mean is due to excessive rainfall, as is shown in Fig. 5, and the subsequent flood.

Here we find a relation between the early and late flowering of both Sail and Aus and their respective yield in *chhataks*.* In the case of Sail the majority of the varieties which flowered late were found heavy yielders, while in the case of Aus no marked difference was noticed in early or late flowering, but an average calculation showed higher yield in favour of earliness. From this it may be assumed that Sail paddy flowering late and Aus paddy flowering early favour the yield.

Sometimes insect attack or flood causes improper flowering so as to decrease the yield to a large extent. Even the lack of adequate amount of rainfall causes a good many number of empty glumes.

Variation in tillering.

Generally, Sail paddy tillers more than Aus. The tillering of Sail is almost three times as much as in Aus and so the yield which will be shown later. The variation in mode, mean and coefficient of variability is rather limited, as is shown in Table II and the curves in Fig. 2, and so is the percentage of error in each case. In majority of cases it is found that where tillering increases yield follows the same. It has also been noticed that some varieties having a large number of tillering have loose or short ears and in some there is a tendency to produce empty glumes both of which are detrimental to the cause of yield.

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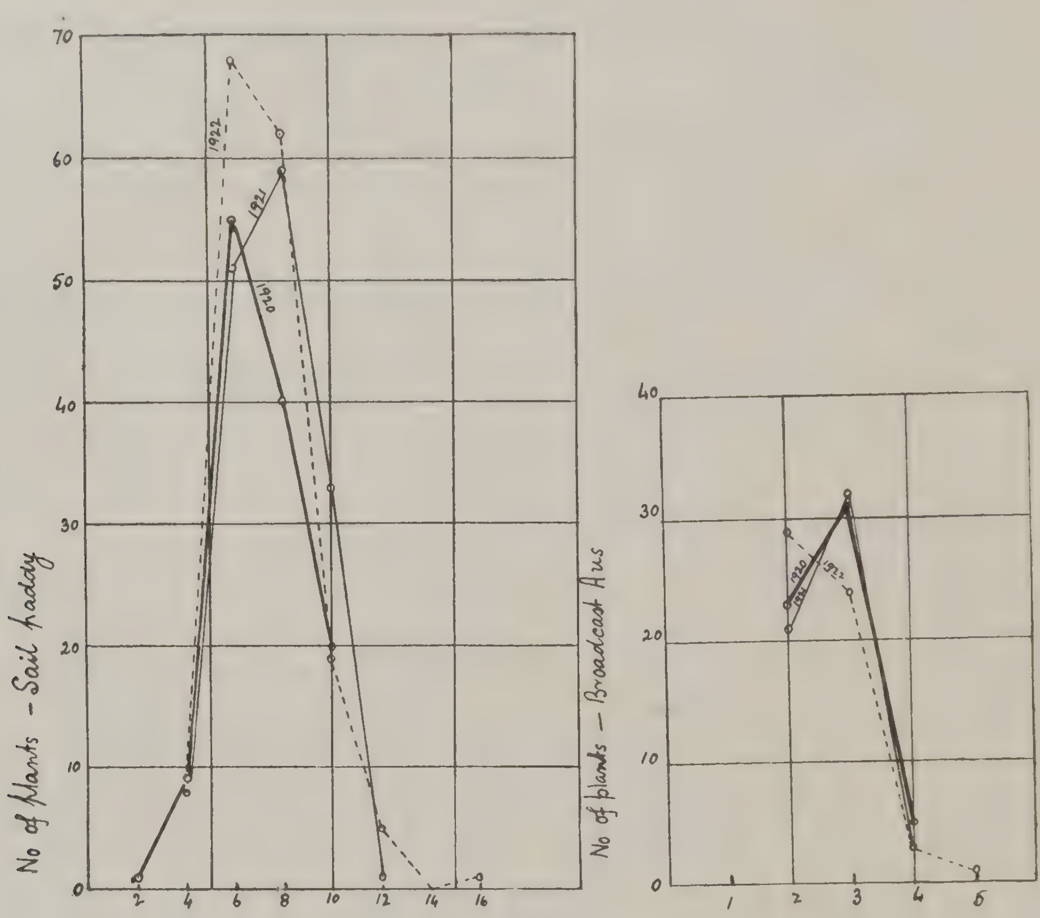
* 1 *chhatak* = 2 oz.



Number of tillers per plant (average of 10 plants).
FIG. 2. Curves showing the number of tillers per plant (average of 10 plants) in Sail and Aus paddies for the years 1920–1922.

TABLE II.

Showing the mode, mean and coefficient of variability and percentages of error in tillering of Sail and Aus paddies.

	Year	No. of varieties	Mode	Mean	Coefficient of variability in percentage
1. Tillering of Sail ..	1920	125	6	7·1	24·5 (± 1·11)
	1921	153	8	7·6	22·9 (± 0·93)
	1922	153	6	7·9	25·0 (± 1·02)
2. Tillering of Aus ..	1920	59	3	2·7	22·0 (± 1·42)
	1921	56	3	2·7	19·0 (± 1·24)
	1922	57	2	2·6	25·7 (± 1·73)

VARIATION IN LENGTH OF STRAW.

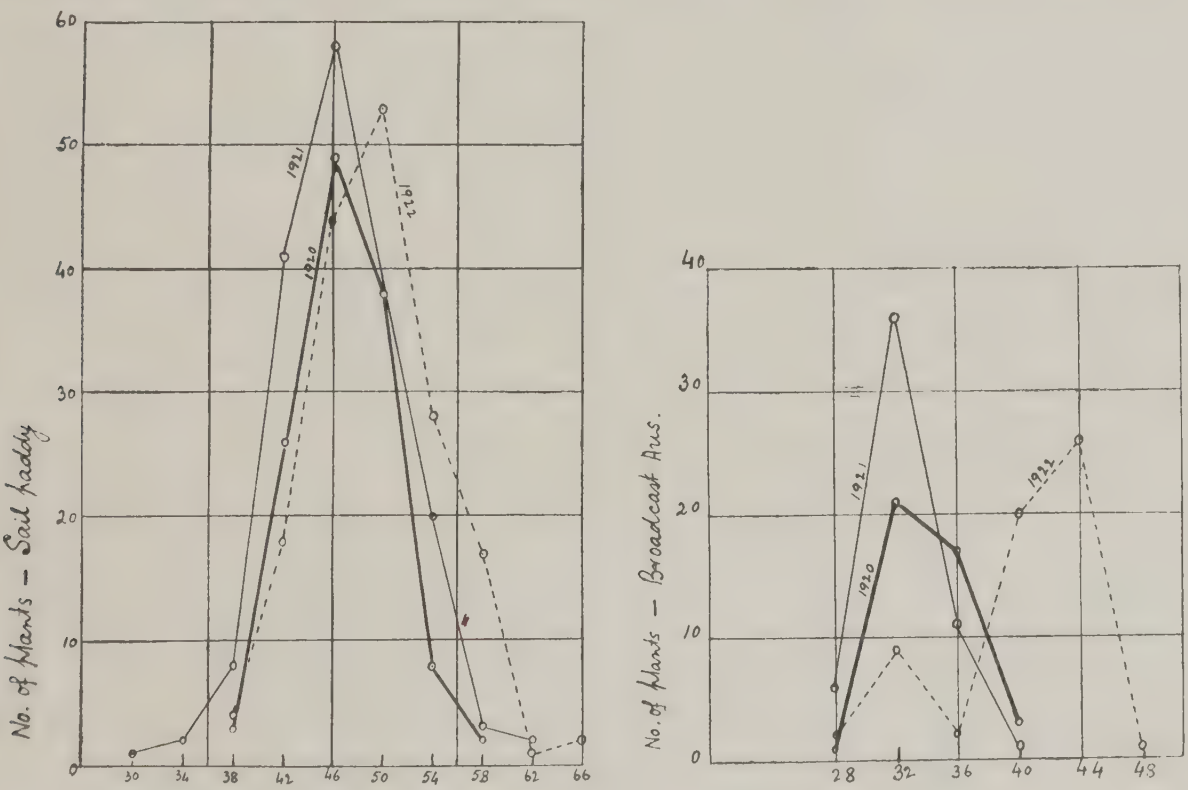
Length of straw mostly varies with the supply of water. Though usually one seldom expects any definite relation between the length of straw and yield, it has, however, been found by calculation that length of straw favours the yield in both Aus and Sail paddies.

TABLE III.

Showing the mode, mean, coefficient of variability and percentage of error in length of straw of Sail and Aus paddies.

	Year	No. of varieties	Mode	Mean	Coefficient of variability in percentage
1. Length of straw in Sail (in inches)	1920	126	46	46·9	8·3 (± 0·35)
	1921	173	46	46·6	10·3 (± 0·40)
	1922	167	50	49·5	10·3 (± 0·38)
2. Length of straw in Aus (in inches)	1920	42	32	34·1	7·6 (± 0·56)
	1921	54	32	32·5	7·3 (± 0·47)
	1922	60	44	40·1	11·9 (± 0·73)

From both Table III and the curves in Fig. 3 it is evident that there is a certain degree of variation in the length of straw in three successive years in their mode, mean and coefficient of variability.



Length of straw in inches (average of 10 plants).

FIG. 3. Curves showing the length of straw in inches (average of 10 plants) in Sail and Aus paddies for the years 1920–1922.

The percentage of error is also very small, as is shown in the table. Among the mean a great deal of variation is noticed in 1922 both in Sail and Aus. This is due to favourable rainfall, as is shown in Fig. 5.

Variation in yield.

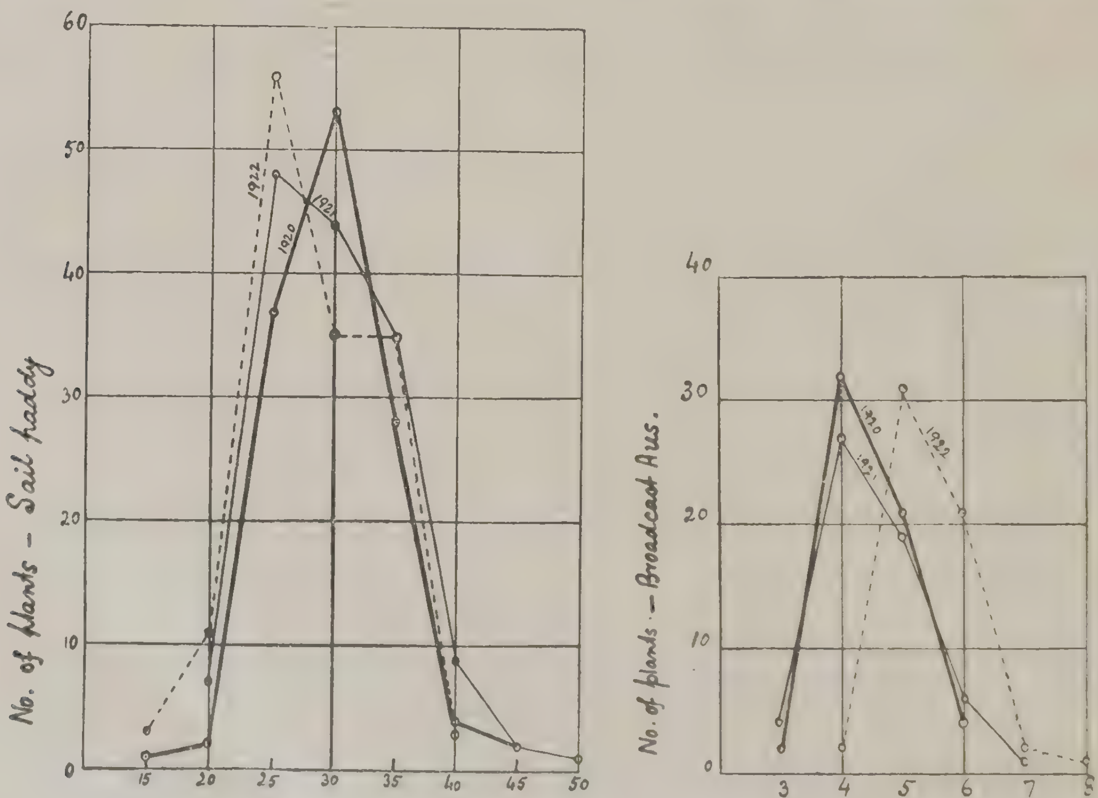
The yield of paddy usually depends on the normal vegetative growth and the normal distribution of rainfall, the latter of which is the most important. Although the yield varies from year to year its variation is limited both in Sail and Aus.

Table IV.

Showing the mode, mean, coefficient of variability and the percentage of error in the yield of Sail and Aus paddies.

	Year	No. of varieties	Mode	Mean	Coefficient of variability in percentage
1. Yield of Sail (in *chhataks*)	1920	127	30	29·9	15·6 (± 0·68)
	1921	146	25	30·0	18·5 (± 0·71)
	1922	143	25	28·4	18·5 (± 0·76)
2. Yield of Aus (in *chhataks*)	1920	59	4	4·5	14·9 (± 0·94)
	1921	57	4	4·5	18·7 (± 1·22)
	1922	57	5	5·5	12·7 (± 0·81)

In Table IV and the curves in Fig. 4 it is clearly shown that the mode in yield is between 25 and 30, and 4 and 5 *chhataks* in Sail



Yield in *chhataks* per 100 plants.

Fig. 4. Curves showing the yield in *chhataks* of Sail and Aus paddies for the years 1920–1922.

and Aus respectively on an average of 100 plants. The mean stands within a narrow limit and so is the coefficient of variability and the percentages of error which are between 15·6 ($\pm$0·68) per cent. and 18·5 ($\pm$0·76) per cent. respectively.

Relation between yield, flowering, tillering and length of straw.

In order to show the relation of flowering, tillering and length of straw to the yield of crop in both Sail and Aus classes, a table has been drawn below on the basis of the high-yielding varieties on the right hand side of the yield curves corresponding to the varieties which have the largest number of days in flowering, the largest number of tillering and the longest straw in each class.

Table V.

Showing the relation between high yield and flowering, tillering and length of straw in Sail and Aus on the calculated average of three consecutive years from 1920 to 1922.

Flowering.

	Class of paddy	High yielding varieties	Early	Late	Ratio in favour of
1.	Sail	45	19	26	Late character 1 : 1·39
	Broadcast Aus ..	26	15	11	Early character 1 : 1·36

Tillering.

	Class of paddy	High yielding varieties	Light	Heavy	Ratio in favour of heavy tillers
2.	Sail	45	22	23	1 : 1·65
	Broadcast Aus ..	27	11	16	1 : 1·45

Length of straw.

	Class of paddy	High yielding varieties	Short	Long	Ratio in favour of long straw
3.	Sail	45	21	24	1 : 1·40
	Broadcast Aus ..	24	7	17	1 : 2·43

In considering the high yielding varieties which come on the right hand side of the curves of yield in both Sail and Aus from the arithmetical mean in each case, the ratio of high yielding varieties in relation to their early or late flowering, heavy or light tillering and short or long straw are clearly shown. From the table we

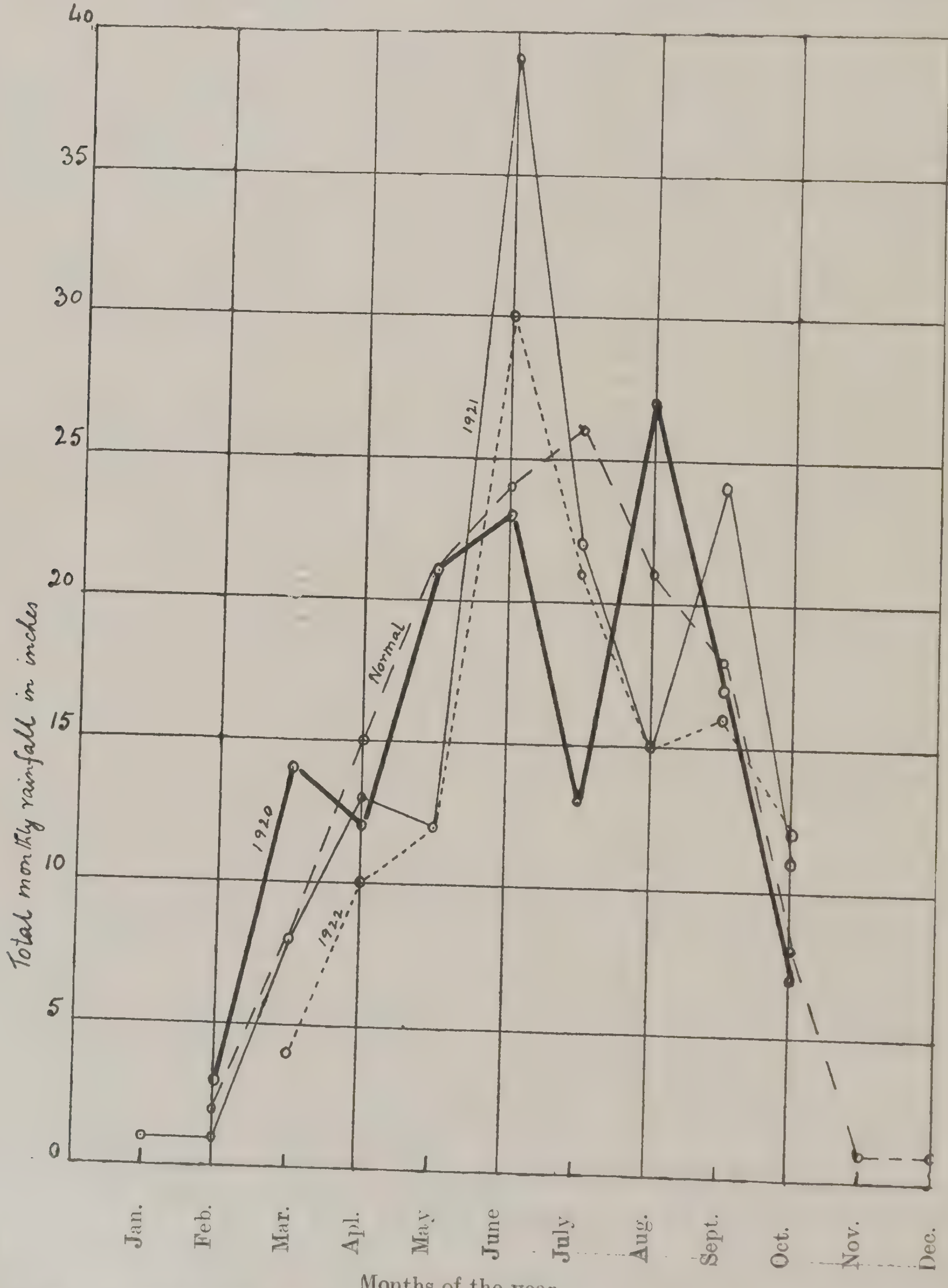


FIG. 5. Curves showing the total monthly rainfall in inches for the years 1920–1922 and the normal rainfall for the last 10 years at the Karimganj Farm.

find that in the case of flowering lateness in Sail and earliness in Aus have advantages to favourable yield in the ratio of 1 : 1·39 and 1 : 1·36 respectively. The tillering of Sail and Aus shows a corresponding ratio of yield in favour of heavy tillering by 1 : 1·65 and 1 : 1·45 respectively. Similarly the length of straw shows a ratio of yield to length by 1 : 1·40 and 1 : 2·43 in Sail and Aus respectively in favour of long straw.

It may be added here that in the rainfall curves in Fig. 5 attempt has been made to show the total monthly rainfall in inches at the Karimganj Farm for the years 1920, 1921 and 1922 with a normal rainfall curve which clearly shows the excess of precipitation for the years in question.

Summary.

(1) The flowering of Sail is timely fixed, i.e., they flower in a fixed time of the year irrespective of the date of sowing, while that of Aus is periodically fixed, i.e., they flower after a certain period irrespective of the date of sowing.

(2) Other things being equal the seasonal variation in our cultivated plots is limited.

(3) Growth and yield of rice plants vary with the distribution of rainfall.

(4) Flowering, tillering, length of straw has a relation to yield.

RESEARCH WORK ON ANIMAL NUTRITION IN INDIA.*

BY

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Up to the present animal nutrition has not been scientifically studied in India. Accurate information regarding digestibility or nutritive values of Indian foodstuffs does not exist, there are no data to show either the requirements of Indian breeds or the effect of extreme seasonal climatic changes upon these requirements; very little is known concerning the distribution of vitamins in Indian foodstuffs and it is impossible to say how far the available proteid foods are deficient in essential amino acids.

These are some of the lines of enquiry along which fruitful results have been obtained in other countries and they can be expected to yield valuable information here too.

Indian conditions are, however, peculiar in many respects. It is, therefore, to be expected that other problems are likely to be quite as important here. For example, a study of the nutritive effect and proper utilization of very coarse fodders is a subject which probably deserves greater attention in India than it has received elsewhere. In undertaking the study of animal nutrition in this country, therefore, the first question which has to be faced is the selection from this unlimited field of enquiry of such lines of work as must be deemed of prime practical importance. When commencing work at Pusa four main lines of enquiry were selected, namely, (1) digestion coefficients, (2) nitrogen metabolism, (3) maintenance

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* Paper read at the Agricultural Section, Indian Science Congress, Bangalore, 1924.

rations, and (4) digestion of coarse fodders. It is of interest to consider the reasons which led to the choice of these subjects.

1. *The determination of digestion coefficients of Indian foodstuffs.* Without a knowledge of the average digestibility of foodstuffs it is impossible to frame a ration on an accurate basis. We may feed definite amounts, but we have no notion how much nutritive material the animal is receiving, which is a hopeless proceeding. The following results obtained during some of our feeding trials will show the value of digestion coefficients.

	Nitrogen	Digestion
	Per cent.	Per cent.
A. Sample of gram	3·23	79·0
B. Sample of *chuni*	3·16	57·5

The nitrogen or proteid content of these two feeds is similar, but the amounts digested, or the nutritive values, differ considerably. The figures speak for themselves.

The determination of digestion coefficients is evidently an essential preliminary to further work. For this reason, and however great other claims might be, the Section must carry out digestion determinations continuously.

To appreciate our lamentable lack of information on this subject we have only to look at the bulky appendices of digestion coefficients contained in most American books on animal husbandry and dairy farming.

Owing to the fact that many of our foodstuffs are extremely variable in composition, discrimination is required if the work done is to be of general utility. On the whole, grains, pulses and other concentrates from mills are most uniform in composition and attention is being devoted mainly to these at present. The results obtained will undoubtedly be generally applicable.

However, we cannot get very far towards the goal of scientific feeding unless we possess, at the same time, digestion data for green fodders and for bulky sorghum, maize and millet fodders.

That these fodders are extremely variable in composition is well known. I have in this connection recently carried out a series of analyses of such typical fodders from different parts of India. The figures, which will be submitted for publication shortly, show the extent of variation that may be expected.

On account of the variable nature of these products it will not be an easy matter to procure the necessary digestion data ; and in any case hearty co-operation is called for if we are to succeed. To attain the end in view two distinct lines of work have to be undertaken. Firstly, we must determine the limits of variation in chemical composition of these fodders in defined areas, and discover some correlation between seasonal and soil factors on these variations. This is a matter which can only be dealt with by local Departments of Agriculture.

Secondly, digestion determinations must be carried out with materials of different grade as judged chemically. This part of the work has been commenced at Pusa, and the results obtained will become progressively more valuable as information relating to the chemical composition of the fodders grown in different parts of the country accumulates.

The tremendous rôle these fodders play in India justifies the expenditure of a great deal of work on them.

Before passing on, one general remark regarding digestion coefficients is necessary. Digestion coefficients cannot reveal differences in quality depending upon the presence or absence of accessory factors which are imponderable to the chemist and can only be brought to light by biological methods. Work of this nature may become necessary in the near future ; but it is certain that the spade work of digestibility determination must first make some progress to clear the way for more elaborate enquiries.

As a matter of fact, experience at Pusa shows that the long period digestion experiments initiated there are likely to be the most effective means of calling attention to deficiencies in accessory food factors.

2. *Nitrogen metabolism.* The most scarce and the most expensive food ingredient in India and the one which is at the same

time most essential for maintenance of bodily vigour as well as for flesh and milk production is the proteid or nitrogen-containing fraction of the ration.

If we are to utilize to the best advantage this expensive and essential part of the animal's food we must determine the proteid or nitrogen requirements of our breeds ; we have to study the nitrogen economy of our animals ; we have to find out the minimum amounts of nitrogen needed for simple maintenance as well for the production of work flesh and milk respectively ; we have also to seek out optimum rations of the different available nitrogenous foods for these purposes.

In view of the great practical importance of these questions special efforts have been devoted to their study. The subject is undoubtedly a difficult one. We have found at Pusa that such factors as individual peculiarities, irritability of some animals when undergoing tests and climatic changes frequently cause appreciable variations in nitrogen metabolism. We are closely observing these variations for they must in time yield valuable information on fundamental distinctions between our breeds, on the extent to which the climatic factor influences nitrogen metabolism, on the relative efficiency of different proteids and lower nitrogen compounds, and on other important points. The scheme of work laid down is intended to collect data bearing on these questions.

For the present owing to the disturbing factors a considerable amount of work will have to be done to obtain results approximating to normal conditions.

All this work has been very greatly facilitated by, and much of it has only become possible through the use of a new form of nitrogen metabolism apparatus which was devised by me and set up at Pusa a year ago.[1] With the aid of this apparatus a whole series of nitrogen metabolism experiments was commenced. As soon as funds are available for the purpose, this work will be taken up at Bangalore on the lines already laid down.

Our experiments show that at times in some parts of the country the animals are wretchedly starved in respect to nitrogen

[1] *Agri. Jour. India,* XVIII, p. 267.

even when the rest of the ration is ample. In such cases the outgo of nitrogen from the body considerably exceeds the intake, the animals becoming emaciated and prone to disease. A little knowledge concerning the minimum necessary nitrogen ration would greatly improve matters.

A point deserving special attention is the following. When there is a nitrogen deficiency in the food the animal system exerts a powerful effort to conserve the body nitrogen. This fact is strikingly shown by the total amount of nitrogen excreted as well as by the form in which it is excreted. The following figures illustrating this effect were obtained at Pusa.

	Daily total nitrogen excretion	Per cent. of nitrogen excreted as	
		Creatin and Creatinin	Urea
	grm.		
Bullock receiving ample nitrogen ration ..	12·6	14	25·0
The same bullock receiving a deficient nitrogen ration	5·9	24	6·4

These figures have a very considerable physiological significance.

The primary result we require from the nitrogen metabolism work is information relating to the maintenance nitrogen ration, i.e., the amount of nitrogen which must be daily digested by an animal at rest to preserve its nitrogen equilibrium. The following striking figures obtained at Pusa show how this fundamental datum line is determined :

	Nitrogen intake (nitrogen digested) grm. per day	Nitrogen excreted grm. per day	Balance in grm. per day
First test	—2·48	6·34	—8·82
Second test	13·92	13·04	0·88

The figures show that the animal requires to digest somewhat less than 13·9 grammes nitrogen per day to maintain itself. It

should be stated here that the nitrogen maintenance ration for the particular food in question works out to about 34 grammes nitrogen (part being undigested). which shows that unless the fullest information is obtained nutrition data may be most misleading.

Another point to be observed is that a single short period test of the above nature might give entirely misleading results. This is due to the fact that when feeding is not altogether wrong the animal system is able to adjust its income and outgo of nitrogen to a wonderful extent and can maintain an approximate balance for a considerable time before it breaks down. Fortunately with the apparatus set up at Pusa and the scheme of work adopted there it is possible to carry out the tests over long periods. If this work can be continued at Bangalore we may, with confidence, expect to obtain significant results on this scientifically interesting and practically important question.

3. *Maintenance ration.* Passing from the nitrogen maintenance ration we come to the third subject of enquiry, namely. the complete maintenance ration. Figures for maintenance rations for cattle in India are urgently wanted; for even when digestion coefficients are known we can do nothing until the requirements of our Indian breeds have been ascertained.

To obtain more perfect knowledge on this subject elaborate apparatus will eventually be necessary. For the present we can obtain useful data by combining nitrogen metabolism determinations with digestion experiments, by suitably adjusting the food supply and by continuing the tests over long periods. This procedure was adopted at Pusa. The results obtained in some tests, which have been reported in the "Agricultural Journal of India" (Vol. XVIII, p. 459), were as follows: maintenance ration for a 1,000-lb. bullock—0·52 lb. protein, 6·5 lb. carbohydrate and 0·28 lb. fat.

These results are no more than a first approximation; they must be checked and elaborated by other tests on the same lines. Further work will no doubt prove the local (Bihar) bullock to be a very thirfty animal.

4. *Coarse fodders.* The fourth and last subject is concerned with the digestibility of coarse fodders. Only two aspects of this

question, which are of special importance, can be briefly alluded to here.

(*a*) The usual procedure in foodstuff analysis differentiates between crude fibre, the residue which is not attacked by chemical treatment, and the nitrogen-free extract which is completely dissolved by chemical means. It is well known that in some cases the chemically insoluble crude fibre is digested with greater facility than is the readily soluble nitrogen-free extract. In such instances, therefore, the chemical procedure has failed to differentiate clearly between digestible and indigestible constituents.

We have found that this failure of the chemical process is much more marked in our experiments with Indian fodders than in tests recorded from other countries.

To shed light on the discrepancies and hence to obtain a better understanding of the digestion capacities of our animals, we are studying in greater detail the digestion of the various carbohydrates contained in coarse fodders.

(*b*) The work of digestion of such coarse fodders is excessive. Some animals would certainly expend more energy on the digestion work than they could derive from the food digested —a process which is more wasteful to the system than simple starvation. Our task, therefore, is to find out the extent to which our breeds of cattle can avail themselves of these low forms of energy. It is worth observing that information on the potentialities of coarse foods would be specially useful in seasons of scarcity.

In such a brief statement of the case it is impossible to do justice to the importance of the subject. If, however, we take into account the fact that in no country in the world are cattle obliged to subsist on coarser material than they have to do in India, it will be admitted that we must consider this problem also to be one which concerns us specially.

This is a main outline of the work initiated at Pusa. Association with the dairy work at Bangalore will undoubtedly bring to the front nutrition problems connected with milk production and the growth of young stock.

THE CONTINUOUS GROWTH OF JAVA INDIGO IN PUSA SOIL.*

BY

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AND

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In previous publications,[1] including a paper read before the last meeting of the Agricultural Section of the Indian Science Congress (Lucknow, 1923), we have brought forward a good deal ot evidence which bears on the theory of phosphatic depletion in the soils of North Bihar.

In 1919 and subsequent years, when the raintall was scarcely more than sufficient for growth and when floods did not occur, Java indigo did well in Bihar. In 1919 for example, many of the Bihar estates, for the first time after many years, reaped an excellent second cut of indigo. The fact that good crops of indigo are obtained when a moderate and well distributed rainfall occurs without floods and the circumstance that poor yields are always obtained when excessive rainfall and floods are the rule are difficult to reconcile with a soil depletion theory. Such occurrences, however, readily fall in with the view that the real cause of the difficulties met with in Bihar is the water-logging of the pore-spaces. Further, a consideration of the general rural economy of the indigo tract, the fact that this region not only supports a dense population

* A paper read before the Agricultural Section of the Indian Science Congress, Bangalore, 1924.

[1] *Jour. of the Roy. Soc. of Arts*, LXVII, 1919, p. 762 ; *Mem. of the Dept. of Agri. in India* (*Botanical Series*), XI, 1920, p. 1 ; *Agri. Jour. India*, XVIII, 1923, p. 148.

but also exports large quantities of oil seeds, tobacco, food grains and work cattle, and the circumstance that the cultivators never apply phosphates to their land, lend no general support to the view that this artificial manure is necessary.

Is it possible to design a simple and crucial experiment the results of which will finally decide this depletion theory ? Direct field trials with superphosphate have not yielded definite results. Some other method of experiment, in which all disturbing factors can be removed, must, therefore, be devised. If we take a definite volume of the ordinary soil, including the sub-soil, of the tract in question, place it in a lysimeter provided with ample drainage and grow Java indigo continuously in the same soil without the addition of any phosphatic manure at any stage of the experiment, the yields obtained ought to show a progressive diminution if the natural supply of phosphate is a limiting factor. Such an experiment was started in June 1919 and has been continued till the present time. The area of the lysimeter was one-thousandth of an acre and the depth of soil 28·5 inches. The results are given in the following Table :—

TABLE I.

The continuous growth of Java indigo in Pusa soil.

Year	Details of treatment and yield	Total annual yield	
		s. ch.	
1919	June 23—Indigo sown .. Oct. 11—Crop cut, 8 s. 12 ch. ..	8 12	
1920	June 19—First cut, 4 s. 5 ch. .. Aug. 6—Second cut, 1 s. 5 ch. .. Oct. 31—Indigo resown ..	5 10	The lysimeter was not resown in October 1919.
1921	June 7—First cut, 11 s. 2 ch. .. Aug. 2—Second cut, 7 s. 12 ch. .. Oct. 30—Indigo resown ..	18 14	

TABLE I.—*concld.*

Year	Details of treatment and yield	Total annual yield
1922	May 22—First cut, 5 s. 13 ch. .. .. July 8—Second cut, 3 s. 12 ch. .. Aug. 1—400 grammes (8 cwt. per acre) of sugar and 200 grammes (4 cwt. per acre) of sulphate of ammonia added to the surface soil .. Sep. 27—Third cut, 5 s. 12 ch. .. Sep. 27—Upper 9″ of soil mixed with 200 grammes (4 cwt. per acre) of sugar and 750 grammes (15 cwt. per acre) of starch .. .. Sep. 29—Indigo resown	s. ch. 15 5
1923	May 9—First cut, 10 s. 12 ch. .. May 16—672 grammes (13 cwt. per acre) of starch added to surface soil .. July 8—Second cut, 8 s. 11 ch. .. 100 grammes (2 cwt. per acre) of ammonium sulphate added to the surface soil .. .. Oct. 1—Third cut, 4 s. 15 ch. .. Oct. 2—Indigo resown	24 6

It will be seen that not only has the yield not fallen off but it was actually higher in 1923 than in any previous year.

No change was observed in the character of the growth till July 1922—a year of heavy rainfall—when the permeability of the soil began to diminish and drainage became more difficult. In August 1922, the growth began to show all the signs of nitrogen starvation and the leaves turned yellow. The addition of sugar at the rate of 8 cwt. per acre and of sulphate of ammonia (4 cwt. to the acre) soon changed the colour of the leaves and also stimulated growth. The sugar was added to provide carbohydrate for the nitrogen-fixing bacteria. So rapid was the improvement that the third cut of 1922 was practically equal to the first. Sugar and starch were added to the surface soil before the lysimeter was resown in 1922. The starch provided a pure form of organic matter, free from phosphate, which could easily be incorporated with the soil. These materials stimulated growth considerably and also improved the texture of the soil. So rapid was the growth that a good deal of watering was needed in the hot weather and early rains of 1923. This, after a time, began to impair the permeability.

After the second cut on July 8th, the porosity of the soil began to fall off to such an extent that many of the old stumps did not form

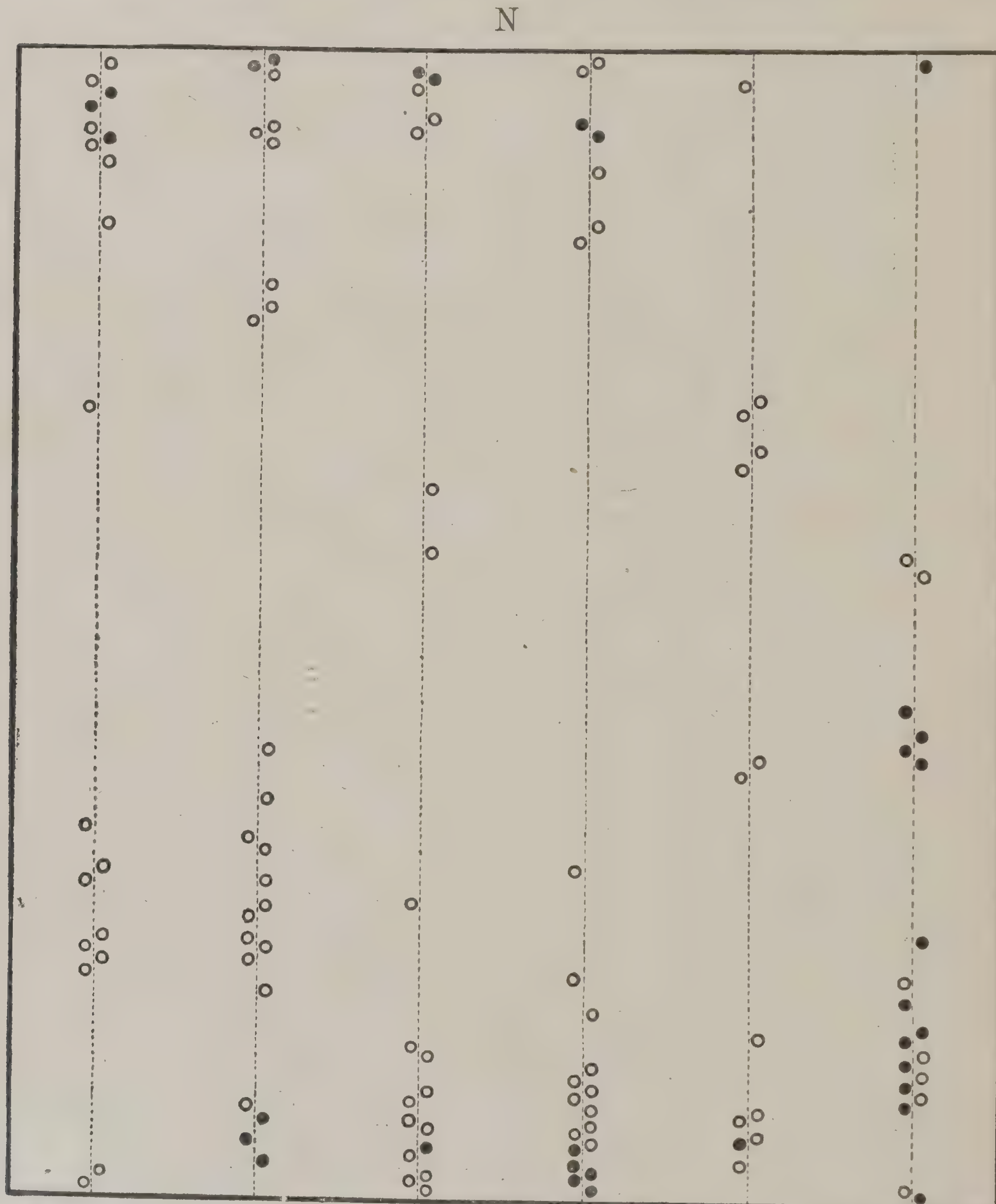

Fig. 1. Plan of continuous indigo plot (third cut of fifth crop). The largest plants are represented by black dots, the remainder by circles.

new growth. Those which survived were not distributed evenly over the lysimeter but occurred near the edge (Fig. 1) where aeration was improved by the contraction of the soil mass on drying. This

left in several places a definite air space between the wall of the lysimeter and the soil. The best plants were nearest the edge. In the centre, none survived. In intermediate positions, the plants which grew did not do so well as those near the margin. These results are explicable on the basis of the water-logging of the pore-spaces but are difficult to understand on the theory of phosphatic depletion. As only a small number of plants contributed to the third cut, the yield in October 1923 was much higher than was expected. The average height of the plants was 57 cm. The sixth crop, sown on October 2nd last, is doing well and so far no signs of failure have been observed.

The yields obtained under these artificial conditions are remarkably high and exceed many of those obtained on the indigo estates. This is surprising considering the depth of soil available is only 28·5 inches, much less than that made use of by the ordinary crop. Further, no rotation is practised in the lysimeter and the land has no rest from indigo. The new crop is sown immediately the roots of its predecessor are picked out of the soil. The only cultivation, beyond surface cultivation, given to the lysimeter is the removal and immediate replacement of the soil just before sowing so that it can be thoroughly aerated. If the supply of phosphate in the Pusa soil is really deficient for the growth of indigo, how are these results possible? Five years' continuous cropping with indigo, without the addition of phosphate at any stage, ought to show a marked diminution of yield. On the contrary, the fertility is increasing now that a suitable method of improving the permeability and the content of organic matter has been adopted.

The only soil deficiency observed in this experiment has been loss of permeability followed closely by want of combined nitrogen. A shortage of nitrogen was expected as experience had taught us that Java indigo, although a leguminous plant, makes great demands on the nitrogen supply and rapidly impoverishes the soil. The difficulties in drainage were somewhat of a surprise as the soil used was above the average in porosity and good under-drainage was provided in the lysimeter. Loss of permeability is a serious factor in the rains as the pore-spaces then become suffused with water

and drainage stops. The soil assumes a wet, jelly-like condition, well known to the cultivators. The indigo plant rapidly reacts to the water-logging of the pore-spaces. Growth slows down, the active roots begin to show marked aerotropism and grow right up to the surface of the soil. The remainder soon die. When the old crop of the lysimeter is removed in October, the only active roots left are those in the upper inch of soil and those in the drainage layer at the base. No active roots occur in the intervening layers. This loss of permeability which, in all probability, is due to the formation of colloids, must very soon lead to a shortage of air in the pore-spaces and must profoundly modify both the flora and the chemistry of the soil. Is it possible by the addition of soluble salts or of substances like sulphur, which yields small quantities of dilute acid on oxidation, to prevent the formation of or to remove these colloidal substances? Preliminary experiments with sulphur and dilute sulphuric acid have markedly increased growth during the rains and have acted on the plant like dressings of nitrogenous manure.[1] The subject is one which might well repay further study not only on the alluvium but also on the black soils. It is not impossible that the results obtained with green manure and superphosphate during the rains are concerned with this question of soil colloids. It is well known that traces of acid have a profound influence on colloids. Superphosphate, when added to the highly calcareous soils of Bihar, rapidly reacts with the calcium carbonate present reverting to the insoluble calcium tri-phosphate. It not only acts as a dilute acid but also produces carbon dioxide as a by-product. Such a reaction might easily prevent the formation of or remove the colloids present. In doing so it would improve the aeration and the efficiency of the green manure. It is hoped that further work will be done on this subject and that no pains will be spared to work out a detailed explanation of this interesting case.[2]

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[1] *Agri. Jour. India*, XVIII, 1923, p. 148.

[2] In 1923-24 in the Botanical Area at Pusa, the efficiency of green-manuring with *sanai* (*Crotalaria juncea* L.) was markedly improved by the addition of small quantities of sulphur (10 lb. to the acre). In the case of wheat and *sarson* (*Brassica campestris*) both the total weight of crop and the yield of seed was increased. The effect on the two crops was similar to that of a dressing of nitrogenous manure

SELF-STERILITY IN GRAPES.

BY

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Certain centres in the Bombay Deccan are among the most important locations of grape culture in India, and Nasik in particular has a very wide-spread reputation for the fruit which it produces. The variety usually cultivated there is known as *Bhokari*, and while this is one which yields well, it is by no means of the highest quality. Two other varieties are actually found grown at Nasik, known as *Phakadi* and *Pandhari-sahebi*, which give very much better grapes, but their yield is relatively so small that their cultivation cannot extend or become profitable.

The question has, therefore, been as to how to get rid of the shy-bearing character of these superior varieties. The matter has been under study for a number of years and certain results have already been obtained. Thus, for instance, Gole[1] at Nasik has had partial success in increasing the yield of *Phakadi* by grafting it on *Bhokari* stock. Prayag[2] claims that the yield has been substantially increased in the case of *Phakadi* by grafting it on *Bhokari* stock, by adopting an overhead system of training, and also by making modifications in the method of pruning. With regard to *Pandhari-sahebi*, experiments have been less in number. This has been due to the fact that though it is a far finer grape even than the *Phakadi*, it is a still poorer yielder than the latter. Of many methods of increasing the yield of *Pandhari-sahebi* tried by Prayag in 1919, the only one which really showed any promise was that of overhead training, but even in this case the average yield per plant was still very low.

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[1] *Agri. Jour. India*, Vol. XIV, Pt. I, p. 116.

[2] *Agri. Jour. India*, Vol. XVII, Pt. I, p. 41 ; *Poona Agri. Coll. Mag. Reprint* No. 16 (1921).

Now in the foreign grape-growing regions the same difficulty had frequently cropped up. An excellent grape has been found which refused to yield well in spite of every effort, and it was early suspected that it was caused by the self-sterility of the pollen of the particular variety. Thus, as far back as 1898, Beach[1] in New York came to the conclusion that while the amount of such sterility depends on climatic conditions, it does bear a definite relationship to the nature of the stamens in the flowers of the variety. It seemed, however, not to be due to the insufficient supply of pollen grains in the anthers. In the following year, work[2] at the same centre (New York) seemed to indicate that many varieties of grapes require crossing for the proper formation of the berries, and later, it was more than suspected that in some cases the cause of sterility was simply the impotency of pollen grains of many good types of grapes. Booth[3] connected the lack of fertility with the shape of the pollen grains and their arrangement in the mass. Again in 1915, Dorsey[4] was able to show a connection between the nature of the stamens and the sterility, and was also able, in the cases in question, to show that there were defects in the pollen grains themselves.

In view of these results and of the relative failure of all other methods in the case of the *Pandhari-sahebi* grape, a thorough examination of the types of grape grown at the Ganeshkhind Botanical Gardens, Kirkee, was undertaken, and it, at once, came to light that there is a close relationship between the length of the stamens and the length of the carpel, and that while, in the fertile varieties, the stamens are quite erect and at least equal in height to the stigma, in the sterile *Pandhari-sahebi*, the stamens are shorter than the stigma and reflexed as well.

In the fertile varieties, the normal and the average length of the stamens corresponds with the longitudinal diameter of the carpel. According to the variety, the filament was found to vary in length from one to three and a half millimetres ; while the

[1] *New York Agri. Expt. St. Bull.* 157, p. 397, 1898.
[2] *New York Agri. Expt. St. Bull.* 169, p. 331, 1899.
[3] *New York Agri. Expt. St. Bull.* 224, p. 291, 1902.
[4] *Jour. Heredity,* Vol. VI, p. 243, 1915

longitudinal diameter of the carpel measured from one and a half to three millimetres.

Again, the study of the way in which the flowers open shows probably the cause of the thinness of the bunch of grapes even in the *Phakadi* variety. In *Bhokari*, our heavy yielding type, the flower opens by the corolla-cap being gently pushed upwards, and the stamens are held in the cap just above the stigma thus assuring its complete pollination; while with the *Phakadi* grape, the corolla-cap is flung off violently and the stamens are driven away—to fertilize the neighbouring flowers or to shed the pollen.

It would appear, therefore, that the lack of yield of the *Pandhari-sahebi* grape in the Deccan is due to the fact that the construction and the opening of the flower are such as to prevent self-fertilization taking place, and the only way of obtaining the fruit of this fine variety will be to arrange for cross-fertilization with a type whose pollen is known to be fertile. Experiments have been made to test the accuracy of these assumptions in both 1922-23 and 1923-24 on a plantation of *Pandhari-sahebi* at Kirkee far away from any other grape garden.

In the first place, seven bunches of flowers were left to see what proportion would form berries. These bunches contained from 135–300 flowers each (average being 222). Not one of them formed a berry, though they were quite healthy. All, in fact, dropped about fifteen to twenty days later.

In the same plantation in 1922-23, four similar bunches of flowers were individually hand-pollinated with the pollen of the self-fertile *Kali-sahebi* with the following results :—

Bunch number	Number of flowers in the bunch	Number of berries set
1	249	106
2	?	81
3	161	64
4	200	85

Taking bunch numbers 1, 3 and 4, it would appear that 42 per cent. of the flowers formed berries. A similar result has been obtained in 1923-24. Thirty-one bunches of flowers were taken and were pollinated simply by brushing the flower of the fertile variety on those of the *Pandhari-sahebi*. The pollination in each case was effected between 9 a.m. and 6 p.m. and the success of the fertilization can be seen between fifty and sixty hours later.

The result was in every way satisfactory. All the bunches of grapes in all cases developed normally and were full, giving excellent bunches of grapes of high quality.

We are now able to account for certain plants of *Pandhari-sahebi* variety giving a good crop both at Nasik and at Kirkee. In each case, these were found to be planted in close association with a fertile type, so that vines of the two intermingled, or the pollen of the self-sterile variety was easily carried to the flower of *Pandhari-sahebi*, thus enormously increasing the chances of cross-fertilization. And there is, evidently, now no reason why the superior type should not more widely extend. It grows well, and to secure a normal yield it is only necessary to mix the plants, in every group, with those of a fertile type, or even better, to take the trouble to fertilize the bunches of flowers by hand with a fertile type in the way described above.

The result we have obtained may have a still wider application than to the *Pandhari-sahebi* type in the Deccan. In every grape-growing area, there are excellent grapes which give little or no fruit. The cause may be similar to that found in the present case, and it may merely mean more adequate provision for cross-fertilization of the flowers, to convert these sterile grapes into types of high productive power.

Selected Articles

THE PART PLAYED BY BRITISH EMPIRE IN THE PRODUCTION OF RAW COTTON.*

BY

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THIS subject is one of the utmost importance to Great Britain, as the provision of new areas for increased supplies of cotton vitally concerns the future prosperity of our great cotton industry in this country. Much has been written about this problem in papers and pamphlets which the British Cotton Growing Association has issued from time to time, and in this paper I shall necessarily have to go over much of the ground again, but the subject is of sufficient interest to justify any repetition. It is hardly necessary to emphasize the vast economic importance of the cotton trade to the welfare of Great Britain; it is the largest manufacturing industry in the country, and it is therefore a matter of grave concern to manufacturers that additional sources of supply should be established over a wider area, in order to prevent, as far as possible, the occurrences of shortages in supplies of the raw material—whether brought about as a result of climatic conditions, insect pests, or the operations of speculators, etc. In normal times Great Britain requires for her own use over 4,000,000 bales; of this about 75 per cent. was obtained from the United States, the remainder chiefly from Egypt, Brazil and other foreign countries, and only a comparatively small proportion from within the Empire. Special attention must be drawn to the

* Reprinted from *Jour. Tex. Inst.*, XV, 6.

present position as regards the American supply, the insecurity of which is the danger with which we are confronted to-day. For one thing the crop from the United States has dwindled considerably in size, and secondly American manufacturers continue to take an increasing proportion of American cotton. There seems not the slightest doubt that the day is not very far distant when the United States will require the whole of its crop for its own mills—if the trend of recent years afford a true guide. Thirty years ago the United States' crop was about 7,000,000 bales, but as the world's demands were less it was sufficient to meet all requirements at a price of about one-third that of present-day prices and still to leave a considerable proportion for the following season. For the period 1901–1905 the average total commercial crop was 11,087,000 bales, out of which America herself consumed 36·2 per cent. For the 1921-22 season, out of a total commercial crop of 11,496,000 bales, she utilized 55 per cent. For the 1922-23 season, out of a total commercial crop of 11,091,000 bales, the percentage taken by American mills was almost 61½ per cent. It is this problem which has so seriously alarmed thoughtful students of the situation. Of course, during the past two years the cotton industry in this country has passed through a period of deep depression, and it is not surprising to find that the consumption of cotton has been somewhat reduced.

Attention has been repeatedly drawn to the grave damage done to the crop in the United States by the Boll-weevil. In 1912 it caused damage to the extent of 3·26 per cent. of the crop. In 1921 these figures had increased to 30·98 per cent. of damage. The menace of this pest cannot be over-emphasized, and the enormity of the damage may perhaps be better illustrated when it is mentioned that in 1921-22 the acreage under cotton was 31,678,000 and the resultant crop 8,375,000 bales. In 1922-23 the acreage under cotton was 34,016,000 and the resultant crop 10,338,000 bales. For the present season of 1923-24 the American farmers planted 39,224,000 acres, and the result is estimated to yield 10,200,000 bales. No certain remedy for the destruction of this dreaded pest has yet been discovered, although several partially successful

attempts have been made to keep it under. It inflicts special injury on the longer staple, because where the Boll-weevil is prevalent the tendency is to plant only early maturing cotton, which is short and generally unsuitable for fine counts. From this it seems certain that the shortage of American cotton is now likely to be constantly recurring if not a permanent difficulty. Then with regard to the Egyptian crop, we are also on the short side in quantity of production. Egyptian cotton fills a place in the British industry which American cotton cannot occupy. Before the war the Egyptian crop had reached a total of approximately 7,500,000 kantars.* During the war period it fell to under 5,000,000 on one occasion, but there was some improvement in 1920 and again last year. One of the principal factors in the diminished supply is the low yield per acre which is partly attributable to (a) the degeneration of the productive power of the soil due to several causes, and (b) the ravages of insect pests, chief amongst which is the Pink Boll-worm. Furthermore, during the war schemes for irrigation, drainage, reclamation of land, etc., had of necessity to be abandoned or suspended. Various attempts have been made to restrict the depredations of the Pink Boll-worm, but so far no absolutely efficacious remedy seems to have been found. During 1919 a Cotton Research Board was created. It is composed of Heads of Sections of the Ministry of Agriculture, assisted by various officials in other Ministries in the Egyptian Government. The Board's function briefly is—to advise the technical section of the Ministry of Agriculture; to co-ordinate scientific experiments; and, in addition, to ensure the maintenance and improvement of the quality and quantity of Egyptian cotton. Extensive laboratories have been staffed and equipped and many experiments started; in fact, much praise is due to the activities of the new organization which has devoted already much study to improving the yield and quality of Egyptian cotton. It is difficult in days such as these to say very much as to the course of prices, but if we eliminate the purely speculative

* 1 kantar=99·5 lb.

view, the trade position seems to be that annual and potential supply of the raw material is definitely inadequate for the requirements of the world. The demand for American cotton is proceeding to-day on a basis exceeding 12.500.000 bales. whereas taking the last three years the supply from America is 2.000.000 bales below this figure. There is no doubt that the future for cotton textiles is sound, because after all they form one of the cheapest forms of clothing, providing garments for the most backward and impoverished people of China, Africa, India, etc., who can only afford a comparatively small amount wherewith to purchase the cloth they use for clothing. If the material is dear they have to be content with a smaller quantity, and consequently the demand per head is proportionately less. Therefore the question of increased cotton supplies must be looked at from the broadest point of view, so that the manufacturing industry may be provided with ample supplies of the raw material at a reasonable price. This can only be brought about by developing to the fullest extent cotton-growing in all parts of the world and at any rate extensions of the cotton-growing area will of necessity have to be found outside the American cotton zone. For the moment it is sufficient to indicate that in the widely scattered lands under the British flag attempts have been made with most encouraging results, proving not only that there is adequate land to grow all the cotton Lancashire can use, but that cotton of an excellent grade and staple can be produced. The quantity grown in the Empire is small in comparison with Lancashire's total consumption, but the rate of progress so far achieved is greater than was the case in the early days of cotton-growing in the United States, and it has not been an easy task. One cannot get natives to grow cotton all at once. For example, in Northern Nigeria, Uganda and Nyasaland, railways had to be built and a great deal of time had to be devoted to the getting out of statistics and estimates for their construction. Then in those countries which had irrigation possibilities, as for example the Sudan, it was necessary to construct barrages and canals, etc. In connection with the problem of transport, I cannot emphasize the fact too deeply that this is the key to the whole scheme of successful and

permanent establishment of cotton-growing in Africa and, in fact, in all the other new or potential fields. At the moment progress is retarded by inadequate transport facilities, even in districts where the industry is of long standing. After this short sketch of the position to-day, I will now pass on to deal with the part our Colonies and Overseas Dominions have played in helping to augment the world's cotton supply, and will first of all deal with India, and would point out at the outset that in weighing up the possibilities for cotton in any country with adequate transport facilities the three most important factors to be determined are—(1) suitable soil; (2) suitable climatic conditions; and (3) sufficient labour.

India. India is already a large cotton-producing country, about five million bales of 400 lb. being produced in 1923. The area under cotton in 1922-23 was 21,792,000 acres, and the yield 5,075,000 bales of 400 lb. each. In 1923-24 the total area sown amounted to 22,941,000 acres, and the total estimated yield is 5,042,000 bales of 400 lb. This gives an average output per acre of 88 lb. of lint, as compared with 93 lb. for the previous year. The principal cotton-growing Provinces and States are—Bombay, Central Provinces and Berar, Hyderabad, Punjab, Madras, Central India, and the United Provinces. India consumes internally more than half her total crop and, further, more than half of her yarn production is counts of 20's and upwards, counts above 22's forming nearly 20 per cent. of her total production, and as this is the style of cotton approaching that suitable for our trade, I propose to deal with this quality only, which is estimated at 1,400,000 bales, over 1,200,000 bales of which is required for her own consumption, plus roughly about 200,000 bales for export, the bulk of which goes to Japan. Japan is India's best customer for cotton, purchasing between 1 million and 1½ million bales, five-sixths of which is very short staple cotton, unsuitable for the requirements of Lancashire. In order to assist in expediting the work of the provision of suitable seed for distribution and growing of improved cottons, the Government of the Punjab has obtained the assistance of the British Cotton Growing Association in the development of an area

of land at Khanewal for the growing of cotton by improved methods, and incidentally the provision of seed for the local farmers. This estate has an area of 7,300 acres. It is laid out in four villages, each with its own mosques and other institutions. The land is let in blocks of 25 acres to tenants, who must possess two yoke of oxen and have three working members in family. A tenant receives 50 per cent. of the proceeds of the crops grown. The project has attracted great interest and its methods are being copied. The principal varieties of cotton grown are the American types, 4F, 285F and a further improved type 289F. The great trouble in India is that although cotton is being produced nine months out of the twelve, owing to the variation of climate the actual growing season in all parts is a short one. In the rain-grown areas the rains are not always well distributed, and in the irrigated colonies in Northern India there are frosts, and these are mainly the reasons why the shorter and more quickly maturing varieties now being produced are so popular. Again, the native is very conservative and prefers to grow something of which he is sure, besides which he is not rich and cannot afford to take risks. This means that continual experiments are necessary to produce a plant which will mature fairly early, possess a longer staple, and give a yield comparing favourably with the local types. The most satisfactory districts for such developments are the canal colonies of the Punjab and Sind, and by careful selection and breeding the agricultural staff have already evolved types which are quite satisfactory as commencement. Another difficulty is that of seeing the grower receives a fair price for his better product, otherwise he is naturally discouraged and will revert to growing those cottons which give him less trouble and with the value of which he is better acquainted. India undoubtedly can produce large quantities of cotton of $1\frac{1}{16}$ in. to $1\frac{1}{8}$ in., the most promising areas being the Punjab and Sind. What is required to get the cotton is continued experiments by experts to produce still more prolific and yet early maturing varieties ; further, to be in a position to deal with pests and disease as they appear, for it has generally been found that exotic types are less immune than the indigenous types. The grower also should receive a price more in

accord with the relative value of his better produce, and some effort must be made to prevent the mixing of American and Indian types at the ginnery. At the moment it is openly done without the knowledge that it is harmful in the extreme. India possesses an excellent agricultural staff, which has done valuable work in the improvement of all crops produced in that country. The Agricultural Service is, however, deserving of augmentation, but unfortunately like many other countries the aftermath of the great war has brought about many changes, and there is little hope of increasing the European staff; on the contrary, there is some considerable danger of decreasing it. Fortunately for the improvement of cotton-growing, the formation of the Indian Central Cotton Committee, which under the Indian Cotton Cess Act (XIV of 1923) was incorporated as a permanent body and its constitution laid down in the Act, is most opportune. It is presided over by the Agricultural Adviser to the Government of India, and comprises on the official side the Director-General of Commercial Intelligence, seven representatives of Local Governments, and four of Native States; on the business side it comprises nine persons nominated by commercial organizations, one representing the Empire Cotton Growing Corporation, four representing cotton-manufacturing or cotton-ginning industries in the Central Provinces, Madras, and the Punjab, and ten persons representing the cotton-growing industry in Madras, Bombay, the United Provinces, the Punjab and the Central Provinces. It receives its funds from a levy of four annas per bale on all cotton consumed in Indian mills and exported from India. The proceeds will be devoted chiefly to agricultural and technological research. Agricultural research is largely provided for by grants to Provincial Agricultural Departments for the undertaking of specific investigations beyond their ordinary activities. Provision for technological research will be made by the Committee under its own direct control. A scheme for the setting up of a miniature spinning plant which contains both ring and mule spindles, including combing machinery, has been developed, and the testing room is fully equipped with the most modern instruments.

The Sudan. This is an immense country—roughly half the size of India. There are fair prospects for growing cotton in the Dongola and Berber Provinces, but owing to the spare rainfall irrigation from the Nile is necessary, and the difficulty is that the water can only be utilized for certain months in the year, as it is required for Egypt. There are also good prospects for American cotton in the rainfall areas south at Senga, Renk and Roseires, but there are other larger propositions in the Sudan which are more certain and which can be more quickly developed by irrigation. The first in importance is a large tract of land south of Khartoum, between the White and Blue Niles, known as the Gezira Plain, which comprises an area of 3,000,000 to 4,000,000 acres which is capable of cultivation by irrigation. Although in appearance this plain looks absolutely flat, the land has a slight slope, giving it a well-defined fall from the Blue Nile in the east to the White Nile in the west, which simplifies the problem for both irrigation and drainage. The scheme for cotton-growing in the Gezira was initiated by the late Lord Kitchener, and an agreement was entered into with a strong group of capitalists to provide the money for the commercial part of developing the undertaking. This body is known as the Sudan Plantations Syndicate, and they have done remarkably valuable development work. The scheme is as follows:—The crops are pooled. The Government of the Sudan provides the land and water, for which it receives 35 per cent. of the gross value of the crops produced. The growers receive 40 per cent. of the same, and the Sudan Plantations Syndicate, who make the minor canals, plough the land, generally supervise the cultivation, provide ginning and storage facilities, and look after the marketing, gets 25 per cent. Operations were started by means of pumping stations erected on the Nile, first at Tayiba, later at Barakat, Hosh, and Wad el Nau, and as a result some 20,000 acres of land have been irrigated and now produce about 20,000 bales of 400 lb. each. The Makwar Dam, near Sennar, $1\frac{3}{4}$ miles in length, stretching across the Blue Nile, is now in course of construction by the Sudan Government, the consulting engineers being Messrs. Coode, Fitzmaurice, Wilson and Mitchell, and the contractors Messrs. S. Pearson and Son, Ltd. It

is expected to be completed by July 1925, when sufficient water will be available to irrigate 100,000 feddans,* providing from 80,000 to 100,000 bales of cotton. The quality of the cotton produced in the Gezira is Sakellarides, which compares most favourably with the best Egyptian types. An adverse factor which came to my notice when in the Sudan was the damage caused by insect pests. The Sudan, like Egypt, is free from the Boll-weevil ; it does not suffer from the Pink Boll-worm to any great extent, but the country is not entirely free from other pests, one being the cotton Thrips, which injures the plant by feeding on the tissues of the leaves and bracts. Aphis is another pest also fairly common.

As previously stated, there are other propositions in the Sudan, but of a minor character—the chief being Kassala, Tokar and Gedaref.

Kassala is situated some 250 miles east of Khartoum. The rainfall here is about 20 inches and coincides with the inundations made by the river Gash, which rises as a result of the rains in Eritrea, Abyssinia, the boundary being only a few miles distant from Kassala. This river irrigates over a length of 60 miles, then loses itself in the desert. The soil at Kassala is exceedingly good, it has dark, rich, black clay, and where tested was from 9 to 12 feet deep. After the water from the Gash—which floods the land in June, July and August—has soaked into the soil, cotton is sown and after October there is no rain. Cotton here gives from 200 to 250 lb. of lint to the acre ; the variety is Sakel, the same as is grown in Egypt, and the staple and quality are excellent. Transport was the missing factor, the cotton having to be sent on camel-back to Port Sudan or Suakin, a distance of 250 miles, and the increase of cotton production was limited only to the camels available for transport. A railway has now been built, and joins the present Port Sudan-Khartoum line at Thamiam, therefore we may shortly expect quite an important increase in the present production of 4,000 bales.

Finally Tokar, twenty miles from Trinkitat, on the Red Sea, is a somewhat similar proposition, the land here being irrigated

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* 1 feddan=1·038 acres.

by the river Baraka. The volume of water is not so large as the Gash, and it is doubtful if more than 50,000 feddans will be available for cotton until some scheme is devised for controlling the waters of the Baraka. A quantity of cotton is, however, grown and the quality is excellent.

West Africa. A great deal of money has been spent in endeavouring to develop the cotton-growing industry in our Colonies there, and although attempts were not successful in some cases, they have been in others. In Nigeria the Association's main efforts have been concentrated. The population of Nigeria is approximately 18¾ millions—larger than that of any British Dependency except India. The area is approximately 335,700 square miles. It is about half the size of the Cotton States of America. The inhabitants are good farmers and the land is closely and well cultivated, and the growing of cotton has been practised there for many years, spun and made into clothing for its inhabitants. The methods of cultivation practised by the natives themselves are the result of long experience, and whether they can be improved upon can only be demonstrated to them and justified adequately by practical proof that some other method is productive of better results. At first in Nigeria cotton plantations were started with American overseers, but these were not successful. The country is now divided into two separate parts known as the Northern Provinces and the Southern Provinces. It is not so much from the Southern as from the Northern Provinces that large results are looked for. In the former we have strong competition in palm oil, palm nuts, ground nuts and cocoa, but in the latter there is practically only ground nuts which go quite well as an alternative crop to cotton. Again, the Northern Province is out of the forest belt. To encourage the small native cultivators to take up the growing of cotton, it was essential that a market for their crop should be practically guaranteed ; that is to say, the native should receive a definite price for his seed cotton when it was grown, and the British Cotton Growing Association guaranteed for twelve months ahead a fixed price, so that the grower when he planted his crop knew what he was going to get. This naturally was very big risk for the Association

to undertake, for although at times profits were made, at others heavy losses were incurred. All the ginning is in the hands of the Association, four large up-to-date pneumatic ginneries being in commission along the Lagos-Kano Railway at intervals of about 60 miles. In recent years determined efforts have been made by the Department of Agriculture, in co-operation with the Association, to improve the cotton coming from Nigeria; the Agricultural Department of the Northern Provinces successfully established a type from the American long-stapled variety, known as Allens. In 1914 the production of this type totalled 11 bales. Not only did this improved type of cotton yield a heavier crop than the indigenous variety, but it also commanded a better price on the Liverpool market, being worth about 150 points premium as against a discount of 100 points for the other. Consequently the Association always offers the native growers an enhanced price, with the result that this improved type is rapidly superseding the local variety, so that from 11 bales in 1914, 855 bales had been reached in 1918, 3,380 in 1920, 8,173 in 1922, and in 1923 the total had reached 12,221 bales. This year the result is estimated at 17,000 bales, a really fine achievement for the Agricultural Department. It seems safe now to predict steady progress in the Northern Provinces proportionately to the increase of transport facilities, the spread of the activities of the Agricultural Department and general progress of the country on modern economic lines.

In the Southern Provinces, however, the industry has a less sure foundation. The climatic conditions cannot, ordinarily, be regarded as favourable to the production of a high grade cotton. Attempts have been made to introduce an exotic type of cotton in the Southern Provinces, but have not yet met with any substantial success. In order to encourage the natives throughout the cotton-producing areas to take greater care in handling and picking their cotton, steps have been taken for all cotton to be graded by Government examiners, and a difference in price is made between Grade I and Grade II in both the improved and indigenous types. There is no doubt that in the course of time the steps which have been taken in this respect will prove beneficial and result in a general

improvement in the quality of the cotton. In Nigeria we possess a field which, with its population and suitable soil, is capable of becoming, next to India and the Sudan, one of the most important cotton propositions in the Empire, but this is not going to be brought about without an expenditure of money and energy, and for success it would appear that the following essentials are necessary—(1) The extension of the present railway system; the construction of light railways to act as feeders to the main or trunk line; and the improvement of roads suitable for motor and other vehicular traffic. (2) The agricultural staff to be largely augmented so that a number of centres may be established to serve as seed farms and as an object lesson to the local farmers.

Uganda. The Uganda Protectorate covers an area of approximately 110,300 square miles, including 16,169 square miles of water, and the population was last estimated to be 3,150,000. It is a blackman's country and here also cotton-growing is a native industry, the crop being produced by thousands of native peasants, European and Asiatic cultivation being negligible, and, speaking generally, this existing system of native cultivation would appear to be the best. The natives cultivate the crop on innumerable small plots, which in the aggregate amount to a considerable acreage. They have really taken to cotton in a wonderful way, the soil is remarkably fertile, and practically every native in the cotton-growing area cultivates his quarter-acre plot of cotton. The first record of cotton exports from Uganda was in 1904 when 54 bales were shipped. In 1908 the quantity was 4,000 bales; in 1914 42,000 bales, which was further increased in 1921 to 81,350 bales. For the current year the estimated acreage is 418,609 acres and a record crop of 100,000 bales is expected. It will thus be seen that it is from Uganda we are at present receiving the largest quantity and, for its class, the best cotton from any of the new fields. The quality is excellent and is of high standard, when marketed in a good clean condition. It has a staple of from $1\frac{1}{8}$ in. to $1\frac{3}{16}$ in., and compares with some of the best American. There are a large number of ginneries in the Protectorate owned by cotton-buying and ginning companies and private individuals.

The Association is also directly established in the principal buying centres. With cotton practically non-existent twenty years ago, it must be admitted that the result obtained in so short a period is most satisfactory ; in fact, cotton has extended so rapidly that it now heads the list of exports, being about 80 per cent. of the total exports of the Protectorate, and reflects the greatest credit on the Agricultural Department and its officers. With improvements in transport, new districts will be opened up, and with a sufficiently large and up-to-date Agricultural Department to maintain the quality and supervise the distribution of seed, it is hopefully anticipated that half a million bales per annum will be produced in this Protectorate.

Nyasaland. The territory comprised in the Nyasaland Protectorate is a strip about 520 miles in length and varying between 50 to 100 miles in width. The area is roughly 40,000 square miles, or about one-third the area of the British Isles. The most southerly portion of the Protectorate is about 130 miles from the sea. The soil and climatic conditions are most suitable for the cultivation of cotton and tobacco—in fact, tobacco is cotton's chief competitor. Cotton is cultivated on the plantation principle. The British Central Africa Co., the A. L. Bruce Estates, Ltd., and James Dickie, amongst others, have large areas under this crop. In 1915 the acreage under cotton was about 29,500, but some reduction took place during the war period, largely due to cotton land being used for tobacco owing to the better price obtained. The yield per acre varies, but with proper care in the selection of land larger yields may be expected. Cotton is also grown by the natives as a native industry, and they in many cases produce good crops, and it has been recognized that what was wanted by these growers was a steady remunerative price instead of greatly fluctuating prices, so that the possibilities in the production of cotton could be proved. Nyasaland cotton generally is excellent in quality, silky, and from $1\frac{1}{8}$ in. to $1\frac{3}{16}$ in. in staple, but too much of the cotton is stained as a result of insect pests. Steps are now being taken with a view to combating these pests. The first recorded export of cotton from Nyasaland was in 1902. The crop in 1916 reached the highest

recorded figure of 3,462,000 lb. During the war the necessity for producing native foodstuffs for the local forces combined with the very high prices for tobacco caused many planters to abandon the cotton industry. The native cotton crop also received a check, but proofs are not wanting that renewed interest is being taken in the industry, and with the view of encouraging the production of cotton by the natives, the British Cotton Growing Association has entered into an agreement with the Local Government, under which the Association for a period of five years purchases all native cotton grown on Crown lands in certain districts at a price to be fixed annually. By this means it is hoped to give the native grower that stability of price without which it was felt that he would never be encouraged to persevere in his efforts. The utilization of agricultural implements and mechanical means of transport is releasing manual labour either for extended agricultural operations or for absorption into native industries. The construction of an extension of the railway from Luchenza station on the existing Chindio Blantyre Railway to the south end of Lake Nyasa is under consideration. The opening of the new Trans-Zambesia Railway between Beira and Muraca on the south bank of the Zambesi opposite Chindio, in July 1922, has already greatly facilitated transport to and from the Protectorate. Until a bridge is constructed across the Zambesi, connection with Chindio is effected by steam ferry. Boll-worm is mainly responsible for the very low yield per acre, but the matter is receiving the earnest attention of the local Agricultural Department. A "Cotton Pest" Act has been enacted and every cotton bush in the country, both European and native, must be uprooted and burnt before the end of November, and the results of these methods have been found very satisfactory.

Tanganyika Territory. Tanganyika Territory, which was formerly German East Africa, is a large tract of country of some 365,000 square miles, the population of the area under British mandatory rule being about 4,000.000. Before the war the Germans had devoted a great deal of attention to the development of cotton-growing. This country does not, however, possess one large uniform cotton zone, but a number of districts the conditions of

which are rather diverse, and each district requires to be treated separately. During the war period, and for a little time afterwards, the industry was allowed to lapse, but an agricultural staff was appointed as soon as practicable and is now at work. One of the districts which showed promise of success is that immediately south of Lake Victoria, known as Mwanza. The Association has erected two ginneries in this district, but the prospects are very uncertain, owing to transport and other difficulties. Of the other areas the principal ones are Morogoro, Kilwa and Lindi, and serious attempts are being made to foster the cultivation of cotton as a native industry. The 1921 crop in Tanganyika produced 7,327 bales, and that of 1922 6,276 bales. In that year there was an approximate increase of 25 per cent. in the acreage planted, but bad weather and pests caused an unfortunate fall in the yield. The estimate for the 1923 crop is 10,125 bales. The native producers have been encouraged to sell all the cotton grown by them and there is little local consumption. In addition to the native industry, cotton is now being grown on a number of estates under European management, either as a full-time or rotation crop, which might well lead to greater developments.

Kenya. The territories comprised under the name of Kenya Colony and Protectorate, until recently known as British East Africa Protectorate, consist of about 240,000 square miles. On the west the colony adjoins the Uganda Protectorate, and on the south the mandated Tanganyika Territory. The high prices ruling for cotton in 1919 and early in 1920 caused some attention to be given to cotton by European farmers, and a small acreage was planted on their estates along with other crops. In the Kavirondo and some of the other native reserves a large extension of the area under cotton was also made. In order to develop the agricultural resources and wealth of the colony, it is essential that native agriculture should be fostered, but in any circumstances progress must inevitably be comparatively slow, and to succeed in effecting a substantial improvement in native agricultural practice and an increasing production, a large number of instructors are required. Hitherto cotton-growing in Kenya Colony has not been a success, preference

being given to other crops. The local Government has now elaborated a certain policy of native development, and with an extension of the railway system, a vast acreage of native reserves and European owned land will be opened up.

Union of South Africa and Rhodesia. Since 1910 cotton has been exported from the Union of South Africa, but the quantity up to 1916 was not very large. In 1919 it was about 2,000 bales, and for the last season about 6,000 bales. Cotton is grown on plantations and on land owned by farmers, and not as a native industry. The chief centres of production are the Rustenburg and Nelspruit districts of the Transvaal, Natal, and Zululand, a large proportion of which is situated on the Pongola Poort and Candover Estates. The results which have been obtained give some promise that the cotton industry is likely to become a permanent one. Besides those districts in the Transvaal and Natal, including Swaziland and Zululand, which are already growing cotton, there are in addition large tracts of land which have a soil suitable for cotton culture. These latter districts are, however, at present uncultivated and their development must largely depend on the question of the labour supply. Although labour is scarce in many districts, and the mines absorb a large proportion of the available supply, there is stated to be in South Africa as a whole a certain quantity of labour which is lying idle or dormant, but which might be put to agricultural work. In order to guard against the introduction of insect pests, stringent regulations have been enacted against the importation of cotton seed and unginned cotton into the Union from any other country except under Government supervision. For the successful development of cotton-growing in South Africa and in all cotton-growing countries, it is of the utmost importance to maintain a pure seed supply. One of the most suitable varieties which has been produced in the Union is the "Bancroft" type, and if this seed can be obtained and kept pure, then it might be continued. That most excellent cotton can be grown has been proved, that there are facilities both in suitable soil and labour for growing a large crop is also beyond doubt, and as the Department of Agriculture is now tackling the problem seriously progress should be well maintained

The newly-established Colony of Southern Rhodesia is a promising area as a supplementary source of supply. It has been known for many years that cotton could be grown, and no doubt the present high prices will help to induce the farmers to consider the question of cotton cultivation on an extensive scale. In North-eastern Rhodesia cotton has also been grown for some years, but the crops for the past three or four years have not been very large. This is partly due to tobacco proving more remunerative and cheap transport facilities being non-existent. Geographically, North-eastern Rhodesia is a part of Nyasaland. Transport is the problem, and it is doubtful if there can be any large development until that territory is connected by railway with either the Zambesi or Blantyre.

Australia. It is now clear that certain parts of the Commonwealth of Australia are capable of producing cotton of high standard and staple, and great efforts are being made to establish the cotton-growing industry. The Association has taken an interest in cotton-growing in Queensland for a number of years, and the following offer was made by the Association in August 1920.

> The British Cotton Growing Association will guarantee for a period of five years a selling price of 1*s.* 6*d.* per lb. of lint for all clean cotton of good quality forwarded to them, freight and insurance paid, for sale in Liverpool. The cotton to be produced from cotton seed such as Allen's Improved, Cook's Long Staple, Egyptian Sakel or similar long-stapled varieties, such seed to be issued by the Queensland Agricultural Department. The guarantee to date from 1st January, 1920, and the Association's total loss throughout the period to be limited to an amount not exceeding £10,000.

The amount of £10,000 eventually was exhausted, and the Queensland Government decided to continue to guarantee the growers a fixed price. Queensland at present is the only Australian State where cotton is grown in appreciable quantities, although the northern parts of New South Wales have made considerable experiments. The area under cultivation for cotton in Queensland

has increased from 166 acres in 1920 to over 100,000 acres in 1924, and in addition it is estimated that between 20,000 and 30,000 acres will be planted in New South Wales this year. The North-west of Western Australia and the Northern territories also have possibilities. The development of cotton-growing in Australia has two interesting features. One is that only white labour is employed, and the other is that the industry is being developed along lines tending to confine cotton production to small areas and incidental to other farming operations. The Commonwealth and State Governments are doing all they can to encourage the cotton-growing industry, and have adopted a bold policy of guaranteeing a price up to $5\frac{1}{2}d.$ per lb. for all first quality seed cotton delivered at the ginneries. The quality of the cotton is excellent. The Queensland Government have further legislated to prohibit the cultivation of ratoon cotton. The Boll-weevil is not yet known, but there are other pests such as the Boll-worm, etc.; therefore by prohibiting ratooning and insisting on the old plants being uprooted and burnt every year, it is hoped to keep the country clear as far as possible of the chief pests which prey upon cotton.

The West Indies. The bulk of the cotton grown in the West Indian Islands, principally in St. Vincent, Montserrat, Barbados, St. Kitts, etc., is what is known as Sea Island, a distinct variety; the superfine type from St. Vincent is the longest and finest cotton grown in the world. With the rapid change that was experienced in the cotton trade from a state of great prosperity to deep depression, the demand for Sea Island cotton declined. The Fine Cotton Spinners' and Doublers' Association, however, boldly came to the rescue and have continued to purchase practically the whole production for several years past. The goods made from Sea Island cotton are largely used for luxury purposes, and will probably be the last to feel any advance in view of the general poverty of the nations. The Pink Boll-worm has also, unfortunately, made its appearance in the Islands of Montserrat and St. Kitts, and although every precaution was promptly taken by the Imperial Department of Agriculture to stamp out the pest, and especially to prevent its spread to other Islands, it is feared the outbreak

will result for a time in some curtailment of the area under cotton. The quantity produced is between 4,000 and 5,000 bales, and is quite sufficient to meet the present demand. Most of the plantations are in the hands of Europeans, although the peasant growers produce quite a fair quantity. An Imperial Agricultural College has recently been established in the West Indies and is situated in the Island of Trinidad. The foundation stone of the new building was laid on 4th January last. It is anticipated that the work to be carried out by this college should be of considerable value in connection with cotton cultivation in all tropical countries.

Iraq (Mandated). Experiments which were made shortly after the Armistice by the Agricultural Department proved that this country offered immense possibilities, the yield per acre in some instances being higher than is obtained in other parts of the world. Owing to the small rainfall, however, cotton will have to be grown under irrigation. The soil and climate largely resemble that of Egypt. The experiments mentioned above indicated that a variety which has been given the name of " Mesowhite " was about the most successful. The great need of Mesopotamia, however, is population. The country is larger than the United Kingdom and yet its people do not number as many as those in the West Riding of Yorkshire. In the winter of 1919-20, the Association sent out a delegation to that country to investigate the possibilities on the spot, the result of which was a decision to commence direct operations and a ginning plant was sent out and is now working at Baghdad. This plant deals with all the cotton at present grown. The production for 1922-23 season was 350 bales, and for the present season about 1,500 bales. Under the more healthy and secure conditions now being obtained, the population will no doubt increase, and with the provision of the necessary capital for development work there is every possibility of obtaining 100,000 bales, which it should be possible to produce on land provided with water from the existing works. But the ultimate possibilities of the country with a sound irrigation system and a largely increased population are estimated at one million bales annually.

Ceylon. Experiments by cotton and rubber planters were conducted over several years, and the Association some years ago erected a small ginning plant, but cotton as a commercial crop was not a success, mainly owing to the excessive rainfall and to the fact that there were other crops which paid the planters better, principally tea, rubber, etc., and consequently the industry was not persevered with. We have not the slightest doubt that cotton can be grown in Ceylon, and at prices ruling to-day it should be a payable proposition, more especially as there is not the same keen competition from other products.

There are also many other places where experiments have been carried out and where a certain quantity of cotton is grown, especially in Cyprus, Malta, Fiji, Palestine, British Guiana, etc. In other spheres the possibilities have not been such as to warrant further expenditure and trouble. The result of the work to-day is that about one-quarter of a million bales of cotton are produced in the new fields of the British Empire, and many of the types are not only equal to but an improvement on similar types produced in America and Egypt. In some colonies cotton-growing has not been attended with the full measure of success which was looked for, but in many places its progress and expansion has quite come up to expectations, and what is of more importance is the fact that the permanency of the industry in those new areas has been established, but we want to see the project carried to maturity, and that is to have the Empire making good any deficiencies in our raw cotton supply, but new and experimental work is of necessity a slow growth.

The magnitude of the task which the Association has set out to accomplish proved too great, for after all they had certain limitations, and as the result of recommendations the Empire Cotton Growing Corporation was formulated, and was established under Royal Charter, dated 1st November, 1921. Under its Charter the Corporation will, amongst other functions, have power to—

(1) Assist in the enlargement and strengthening of the Agricultural Departments of the Dependencies and

Colonies, and to provide facilities for training men for posts under these Departments.

(2) Establish a bureau for the dissemination of information on cotton-growing and to issue a journal containing useful information on the subject.

(3) Undertake the marketing of crops where this will prove of assistance to the local Government. This latter work will doubtless be done in conjunction with the British Cotton Growing Association.

During the war the British and Egyptian Governments controlled the buying and selling of Egyptian cotton, the profits amounting to a large sum. Half of this money was retained by the Egyptian Government, and of the balance which came to the British Government it was decided that one million sterling should be handed over to the Empire Cotton Growing Corporation. Moreover, spinners and manufacturers also approved of the proposal of a levy, which has been made obligatory on all users and is enforceable by law, in terms of an Act of Parliament, which received the Royal Assent in July 1923. The Corporation has already got to work, having experts in South Africa, Australia, Tanganyika and Nyasaland, who are engaged in the production of suitable seed, elimination of insect pests, etc. The British Cotton Growing Association retains its separate identity and will work in close co-operation with the Corporation, only its chief work in the development of new areas will be, where necessary, the handling of the cotton when grown, which comprises the ginning, baling and marketing of it, and attending to its disposal in the home markets. The Association will also attend to the supplying of stores, buildings, machinery, etc., and in many other directions continue to assist the industry for which it has laboured since 1902.

In conclusion, it may be stated that the results have been attained by progressive stages, but they have necessitated a vast amount of closely concentrated work and the task has been no light one. Like every other great undertaking, the movement has needed the helping hand and sympathetic assistance of H. M. Government, especially of the Colonial Office. The Imperial

Institute did most important work in the scientific examination of cotton samples and the provision of men for the Agricultural Department. Last, but not least, a warm tribute must be paid to the Governors and officials of the new cotton-producing countries, who without exception have taken the keenest interest in the work ; but it is upon the Department of Agriculture that the real burden of the day has fallen and to whom the success already achieved is largely due, and I take this opportunity of tendering to all the grateful thanks of Lancashire for the part they are playing in increasing the world's cotton supply.

THE MAINTENANCE RATIONS OF ANIMALS.*

BY

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A MAINTENANCE ration may be described as that which will keep an animal that is in a resting non-producing condition and in good health in the same condition and at the same weight *for an indefinite period.* A diet which keeps an animal at a constant weight and *apparently* in good health for a short period is not necessarily a true maintenance ration. For example, certain monkeys kept in confinement in a zoo which are accustomed under natural conditions to a varied diet, including insects and grubs, may live for a considerable time in confinement on a diet of mixed fruits and nuts. When eventually these animals die, post-mortem examination not infrequently reveals a hitherto unsuspected osteomalacia, evidence that the diet has been deficient. It is, therefore, to be assumed that long before symptoms of illness became evident the animals had been living in a condition of "half-health," hence one would not be justified in regarding this diet as a maintenance ration, notwithstanding the fact that it does maintain life even to the extent of several years.

In connection with the domesticated animals, in many cases it is very difficult to say what really constitutes a true basal ration if it is agreed that the diet must maintain health for a long and not a short period. There are many factors which have to be taken into consideration, any one of which, if neglected, may tend to lower the health-level of the animal. Every basal ration should be constructed so as to allow for sufficient exercise, as a certain minimum of exercise is essential if health is to be maintained. The writer,

* Reprinted from *The Lancet,* dated 19th July, 1924.

when feeding oats stained with methylene-blue to horses for the purpose of determining the rate of passage of food through the intestine, found that a few minutes' walking exercise round a yard caused the fæces to be evacuated several hours earlier than when the same animals were kept standing tied up in a stall. Dogs accustomed to regular exercise, and thus regular evacuation of the rectum and bladder, when kept confined in a cage fail to get rid of their waste products as soon as they should, and thus real health is not maintained. It is well known that cattle and horses when conveyed by ship, even for a short distance, show a gain in weight out of proportion of the amount of food they could have digested. This temporary increase in weight is due to the accumulation of indigestible food and waste products in the intestinal tract. This is a very important point to keep in mind when carrying out feeding experiments with animals confined in cages, for this delay in evacuation of residual matter, if continued for an appreciable period, is bound to have a detrimental effect on the health of the animals.

Requirements for a basal ration.

The requirements for a proper basal ration for animals may be summarized as follows: (1) The net caloric intake must be equivalent to the basal fasting katabolism, together with an allowance for the increased metabolism due to the specific dynamic action of the food consumed. (2) It must supply sufficient net energy for adequate exercise. (3) Additional metabolisable energy may be required simply for the purpose of supplying heat in the case of animals where the critical temperature is of practical importance. (4) There must be sufficient protein to equalize nitrogen outgo. (5) There must be sufficient "coarse" food in the ration to open out the concentrated food and thus allow the free access of digestive juices. (6) An adequate bulk to the ration is necessary to cause the optimum distension of the stomach and intestines necessary for proper digestion and to give that sense of repletion without which the animal will not be contented. (7) The protein and non-protein constituents must be in proper proportion the one to the other, as also must the fat to the protein, for the optimum digestion of the

food to take place. (8) There must be a properly-balanced and sufficient mineral supply to ensure a normal ionic concentration. (9) The food must be suitable for the particular species of animal. (10) An adequate supply of vitamins is essential. (11) Finally, the food must be palatable.

Neglect to study the above points when formulating rations, especially when the object of feeding an animal is to conduct a feeding experiment, may be the cause of very misleading results, and it should be remembered that whilst animals possess a considerable flexibility in their capacity to utilize strange and unnatural food, this power to acquire tolerance is not unlimited.

Maintenance requirements of horses and cattle.

Maintenance requirements of farm animals are sometimes expressed in terms of *net energy*, which is equivalent to Kellner's production starch equivalent, or, on the other hand, in terms of *gross digestible energy*, which is equivalent to Armsby's *metabolisable energy*, or the so-called maintenance starch equivalent. The caloric value of 1 lb. of metabolisable energy expressed as starch is 1,710 kilo-calories (C) ; that of 1 lb. of net energy expressed as production starch equivalent is 1,071 C.

In accordance with our conception of a true basal maintenance ration, the requirements for the maintenance of a horse have been studied by many interested in animal nutrition. A critical study of the investigations that have been made to this end has been provided by Armsby in his "Nutrition of Farm Animals."[1] Armsby accepts the finding of Zuntz and Hagemann, which is that for an animal weighing 1,000 lb. there is required a total of 11,900 C. of metabolisable energy made up as follows :—

Net energy for internal work	4,100 C.
Additional required for heat production	7,800 C.
Total metabolisable energy	11,900 C.

This caloric requirement is not taken to mean the physiological minimum but an economic minimum.

[1] Armsby, H. P. *The Nutrition of Farm Animals*, New York, 1917.

In 1917[1] I estimated the maintenance requirement for horses and, basing my calculations on a study of former investigations and on the rations given in practice, suggested that a total of 13,000 C. of metabolisable energy would meet the demands of a 1,000 lb. horse—that is, a light draught horse—where the temperature of the surrounding air was not too low, and provided that the ration contained sufficient net energy for physiological purposes. It was also assumed that this 13,000 C. would allow for the minimum of exercise required to maintain health.

It would appear, however, to be very difficult, if, indeed, it is not even impossible, to fix with any high degree of accuracy the maintenance requirements of horses and to express them in terms of calories. This is so for two reasons: first, because there is such divergence between the findings of the various investigators as to what constitutes a maintenance ration; and, secondly, because we have but rudimentary knowledge of the real caloric value of the different foods for these animals, either when fed as single foods or in combination, as when a composite diet is given, as, for example, hay, straw and grain. It is well known that the digestibility, and hence the net energy value, of foods varies according to the combination in which they are given.

When calculating the rations of horses, it has been commonly assumed that the same food has an equal value for both the ruminant and the horse, and though Kellner himself says that his "starch values" may be applied to both horses and ruminants, this is doubtful—at least with a number of foods. Indeed, Armsby gives a much higher value to some foods for the horse than he does for ruminants, so that as some people use Kellner's figures and some Armsby's, it is not surprising that conflicting results are obtained.

If we assume Kellner's deductions to be correct and that 6·6 lb. of "starch" will satisfy the demands of a resting horse weighing 1,000 lb., then 16 lb. of "good" quality meadow hay will

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[1] Linton, R. G. The Maintenance Requirements of Horses. *Vet. Jour.*, April 1917.

constitute a maintenance ration so far as its energy value is concerned, since this quantity of hay has a metabolisable energy of 12,483 C. and a net energy value of 5,355 C. We know in practice that 16 lb. of hay is fully as much as an animal of this size could eat in a day. If we refer to any published tables of food values, we find that, while it is stated that 16 lb. of "good" meadow hay has a net energy value of 5,355 C., an equal quantity of "very good" meadow hay had a net value of 6,954 C. So that here we have a difference of 1,600 C. in a diet of 16 lb. of hay, according to whether the feeder classes it as good or very good. To illustrate still further what confusion exists regarding food values for animals and their application when an attempt is made to construct a diet on "scientific" lines, we may refer to an example of a maintenance ration for a bullock given by Prof. T. B. Wood in his recently-published "Animal Nutrition."[1] On page 169, Wood quotes Kellner's figure for the net energy value of barley straw at 209 C. per lb. and Armsby's figure at 366 C. per lb. Accepting the latter figure which, as he says, was determined much more recently, Wood considers that 17 lb. of barley straw will supply sufficient net energy for the maintenance requirements of a 9 cwt. bullock, that is, 6,000 C. of net energy. (This ration is, of course, deficient in protein, as Wood points out.) In subsequent pages, when compounding rations containing barley straw for bullocks, Wood makes use of Armsby's figure, but in his table of food values leaves the agriculturist to construct his rations from Kellner's figure, which is the one, rightly or wrongly, that is in general use. What this difference in values means is made clear when it is understood that if Armsby's figure is used, then 16·5 lb. of barley straw will presumably supply the 6,000 calories required, and if Kellner's be utilized, then no less than 28·7 will be necessary. If Armsby's figure is right, then Kellner's must of necessity be wrong, and as dairymen have been in the habit of constructing "scientific" rations for their cows from Kellner's figures, they will be perturbed at finding their careful calculations liable to so great an error.

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[1] Wood, T. B. *Animal Nutrition*, Cambridge, 1924.

Fallacies to be avoided.

Attention is drawn to the above simply for the purpose of emphasizing the danger of utilizing values that are assumed to be correct. When we consider still further the great variation that exists in the quality of the foods given to animals, the divergence in views among those who have studied animal nutrition as to the energy required for maintenance, the fact that in many instances food values, such as they are, for ruminants are assumed to be applicable to the horse and, indeed, even to the pig, and many other conflicting assumptions, one is naturally led to ask, how is one to determine what are maintenance rations for the various domesticated animals ? It would appear to be necessary before conducting a feeding experiment for the purpose of determining a fine point in animal nutrition to find out the maintenance requirements for each animal for the particular food used. This can only be done by careful and prolonged experiment.

Having determined the maintenance requirements of an animal of any given weight, those for other animals of the same species, but of different weights may be calculated approximately by means of the well known surface law of Rubner. Though not sufficiently accurate for experimental work, this method may be applied to everyday use provided that it is not interpreted too literally. A considerable margin for error must be allowed. Estimates of the weight of horses are often exaggerated. The writer found the weight of British Army horses in good hard-working condition, not fat, to be as follows : Heavy draught mules 1,350 lb., heavy draught horses 1,300 lb., light draught horses 1,150 lb., light draught mules 1,100 lb., riders first class 1,075 lb., and riders second class 975 lb. The average weight of heavy draught horses kept in a fatter condition than those in the army is 14 cwt. It is an exceptional animal that weighs over 16 cwt., though some approach a ton in weight.

A maintenance ration for horses that in the past few years has been well tested is that laid down by the Ministry of Agriculture for horses exported from this country to Europe. For horses of the larger type this is 15–20 lb. per day, for smaller animals 10–15 lb.,

and for small ponies and asses 5–10 lb. The average weight of these animals, excluding small ponies, is 11 cwt. Some few months ago the writer had a consignment of 22 horses weighed immediately before embarkation and again immediately after disembarkation at Antwerp. Every horse showed a marked increase in weight, and while, as stated before, this increase is in part undoubtedly due to incomplete evacuation of the intestinal tract, it at least indicates that the quantity of hay consumed was not below maintenance requirements.

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Notes

OBSERVATIONS ON THE FEEDING OF HORSES ON *LATHYRUS SATIVUS*.

THE question of the poisonous properties often ascribed to *Lathyrus sativus* (a small and somewhat three-cornered mottled pea) by older writers has recently been under investigation, not with a view to utilizing the grain as animal food, but to arrive at some practical decision as to whether or not a small percentage as an adulterant to gram might with safety be allowed in animal rations.

To arrive at some idea of the percentage of *Lathyrus sativus* contained normally in gram as purchased and supplied to the Army, samples were obtained from stations covering practically the whole of India, these were carefully hand-picked and the following adulterations recorded :—

Station	Percentage *Lathyrus sativus*	Station	Percentage *Lathyrus sativus*
Risalpur	0·05	Secunderabad	..
Rawalpindi	..	Mhow	0·11
Jubbulpore	0·05	Ambala	..
Jhansi	0·04	Kirkee	0·06
Nowshera	0·11	Allahabad	3·87
Bangalore	0·22	Lucknow	3·37
Delhi	..	Muzaffarpore	0·05
Meerut	0·41	Quetta	..
Lahore	0·80	Karachi	

Records available contain no mention of ill effects of feeding gram thus adulterated to animals.

Following on this, feeding experiments were carried out at the Station Veterinary Hospital, Lucknow, and as it has been

suggested that the poisonous properties attributed to *Lathyrus sativus* may be due to contamination by other small seeds not identified, the *Lathyrus sativus* was cleansed of all other grains before feeding—from 16 maunds (1,280 lb.) of *Lathyrus sativus*, 30 lb. of other grains were extracted.

Seven horses were selected for the experiment which was continued over a period of 35 days.

Two horses received 10 lb. *Lathyrus sativus* per diem with chaff and hay.

Two horses received 5 lb. *Lathyrus* per diem with 5 lb. bran, also chaff and hay.

Two horses received 2 lb. *Lathyrus*, 4 lb. bran, 4 lb. barley, chaff and hay.

One horse received gradually increasing quantities of the seeds removed from the *mutter* pea by screening, starting with 2 oz. four times a day up to 8 oz. four times a day, in addition to the ordinary hospital diet.

It was found that the animals had considerable difficulty in masticating the grain (*Lathyrus sativus*), therefore from the 3rd day onwards it was given crushed.

All the animals were either ridden or lunged twice a day.

Temperature, pulse, and respiration of all animals remained normal throughout the time they were under observation.

The only abnormality noticed was that one horse showed inco-ordination of movement on the 17th day which was more marked on the following day; afterwards the animal improved and became normal although no alteration was made in diet and the incident was probably not attributable to *Lathyrus sativus*.

As a final experiment all animals in hospital received 1 lb. of *Lathyrus sativus* per diem for 4 days. Nothing abnormal was noted.

These observations are of interest. The evidence of older observers that lathyrism (paralysis) in animals does at times result from feeding *Lathyrus sativus* cannot be dismissed.

It may be that the grain is only poisonous:—

(*i*) Under certain conditions of growth.

(*ii*) Intermittently as in the case of linseed and mustard as recorded by Major-General Sir John Moore, K.C.M.G., K.C.B., F.R.C.V.S., Mr. H. Tudor Hughes, B.Sc., F.R.C.V.S., and Mr. G. T. Dunne, F.R.C.V.S., in the "Veterinary Journal" of January 1924, the poison in such cases being due to a glucoside formed under certain conditions, e.g., fermentation.

This view appears to be the most likely one and is supported by the fact that the poisonous effects in all these cases are reported to be destroyed if the grain is boiled, but this, however, was not confirmed in further experiments on three horses receiving daily 2 lb. of *Lathyrus sativus* for a period of 2 months after it had been soaked for 12 hours and fermented.

The results of the experiments lead one to conclude that the adulteration of gram as normally supplied to the Army in India can be ignored as far as it is likely to produce any ill effects on animals. [W. H. WALKER, LT.-COL., R.A.V.C.]

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UNITED PROVINCES POULTRY ASSOCIATION.

ALTHOUGH the model farm of the United Provinces Poultry Association at Lucknow was to a large extent wrecked by the devastating floods of September 1923, which involved the removal of the entire stock of 450 birds to very cramped quarters for over a month just at the time when the breeding pens had been mated for the season, the financial aspect of its working, as disclosed in the fourth annual report for 1923-24, was quite satisfactory. The gross receipts of Rs. 9,513 not only covered the actual working of the farm but also provided the salary of Rs. 300 per month paid to the farm manager which, if the farm were a private concern, would be profit to the owner-manager. When it is remembered that the farm carries only a hundred head of breeding stock, there will remain no doubt that there is scope for reliable commercial poultry farms in the country.

The educational side of the Association's work has largely developed and is by no means confined to the United Provinces

only. The winter classes for students are well attended, and during the year under report over a dozen lads were fully trained in poultry farming. The success of the annual egg-laying competition and all-India show has created so much interest in the countryside that poultry shows have become prominent features of various agricultural fairs held in the province, and at the Etah Exhibition as many as 2,000 birds were offered last year for competition. It is also gratifying to know that many Indian zemindars are opening poultry farms on their own account with the foundation stock supplied by the Lucknow farm, and there is a growing demand for trained managers. Although considerable stimulus has been given to this valuable cottage industry by the activities of the Association during the last four years, much remains to be done, and it is to be hoped that the Association with its energetic Secretary will get a fresh lease of life when the experimental period terminates this year.

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AMERICAN COTTON SITUATION.

"The Manchester Guardian Commercial" of 21st August, 1924, has issued its second annual review of American cotton. The progress and prospects of the new cotton crop are very fully considered, special attention being paid to the part played by the weather and the Boll-weevil. Methods of fighting pests, as well as methods of cultivation, fertilization and marketing are dealt with in so much detail that the supplement provides a valuable guide to cotton-growers in the United States as well as in the new fields.

Mr. W. G. Reed in reviewing the past season writes :—The season is closing with sufficient cotton on hand to meet present requirements, and with the whole cotton trade anxiously following new crop prospects. There are grave fears that the early movement will not be sufficient to provide cotton for the increased demand expected from spinning mills. The carry-over to the new season is more than half a million bales smaller than that of a year ago, which at that time was thought to be lower than was consistent with safety. The trade, however, has managed to get through

another year of approaching famine, but only because of sharp reductions in consumption; with the impoving trade which many competent observers expect in the early fall supplies of cotton will be little more than adequate; the size of the new crop, which was considered of prime importance a year ago, is of even greater moment this year, and until an adequate crop is assured nervous markets must be expected, and a cloud no bigger than a man's hand in the southern skies will crowd telegraphs and cables with messages of hope or fear to the spinners of the world.

Mr. C. T. Revere, of the New York Cotton Exchange, comments on the new crop as follows :—The two Carolinas each promise a shorter crop than last season. North Carolina has suffered from a late start that was complicated by too much rain in June and early July. The situation there has improved considerably of late, but the production probably will fall considerably below last season, with fair indications for a minimum of 800,000 bales. South Carolina is in somewhat the same position as its northern neighbour. The Piedmont districts have done fairly well, but there has been too much rain elsewhere until recently. The State might run close to 800,000 bales, but a fairly safe minimum, barring unusual weevil damage not now indicated, would be 700,000 bales.

Georgia, in my opinion, will furnish one of the surprises of the crop season. Though some estimates are for a yield of 1,000,000 bales, it would not be surprising if the State came closer to 1,500,000 bales, remarkable as such a recovery may appear. The absence of heavy weevil damage furnishes the explanation. Alabama stands a chance of raising about as large a crop as two years ago, as weevil damage so far has been comparatively slight. Mississippi, it would seem from current reports, should go well above 1,000,000 bales, and might easily reach 1,200,000. Tennessee is problematical, although 300,000 bales is apparently a reasonable minimum. Louisiana has suffered from heavy drought, but has escaped the weevil damage that has caused such havoc for a number of years. No guess could be made as to its prospects. Arkansas may fall as low as 800,000, but there are some very good judges of crop conditions in that State who estimate the yield at 1,000,000 to

1,200,000. Oklahoma has scored a remarkable recovery, with excellent prospects for a yield above 1,000,000 bales. The far western States of Arizona, New Mexico, and California all have prospects for the largest crops in their history.

As to Texas, August will have to tell the story. Anything can happen there, but some portions of the State already have a fairly large crop made in well-developed bolls. This is particularly true of the Red River section of North Texas and in portions of West Texas. South-west Texas has had rather too much rain. West Texas has had no such drought as prevailed over that district last season, though the benefits accruing from scattered showers, ranging from one-third of an inch to two inches, represent a question open to controversy.

Mr. G. W. Fooshe, writing on the influence of weather on the yield, reports that Boll-weevil emergence this season has proved strikingly light as compared with other more recent years. It may also be noted, in this connection, that infestation up to the middle of July was exceedingly light in practically the whole of the cotton-producing area. Too much rain has fallen in the Carolinas and Georgia, and there is fear that, if these are unduly prolonged, the foundation may be laid for rapid spread of these pests. But, taking the remainder of the belt, rainfall during the thirty or forty days prior to mid-July proved exceedingly light. Furthermore, with the exception of a few days of cool weather round the fourth of the current month, temperatures have been abnormally high. Even in June temperatures ranging from 100 to 112 degrees maximum prevailed over the greater portion of Texas and Oklahoma, while maxima of 90 to 95 appeared in the central valley States and the south-east. The heavy rains in the South Atlantic States are keeping temperatures comparatively low there, but they are above the seasonal average in all the remainder of the cotton-producing area.

Prevalence of these high temperatures is tending to keep infestation down to pretty small proportions. At the same time, absence of anything beyond widely scattered showers is making it possible for planting interests, equipped to do so, to use calcium arsenate and other poisons with a very high degree of effectiveness.

Thus with the possible exception of North Carolina, South Carolina, and Georgia, where some increase in infestation is reported, there is ground for the hope that weevil may prove far less numerous and far less destructive than in any recent year. Already reports are coming in from Louisiana, Arkansas, and Mississippi to the effect that, in the absence of weevil of importance, more fruitage has already been taken on by the plants than came to maturity during the preceding season.

The supply of poison for combating the Boll-weevil is dealt with by Miss E. M. Miller of the National Bank of Commerce in New York. During 1923, she writes, about 31,000,000 pounds of calcium arsenate were consumed in the United States. Part of this was used in order to combat the army worm, instead of the weevil. The Standing Committee on Arsenic estimated that 1,674,000 acres of cotton, or 4·4 per cent. of the total American acreage, was treated. Early in 1924 it was stated by the Committee that if the price of calcium arsenate should remain low through the current season—that is, below 13·5 cents per pound, f. o. b. factory—its use this season might double, possible consumption being estimated at from 65,000,000 to 75,000,000 pounds. This amount would treat nearly 4,000,000 acres, or 10 per cent. of the total acreage planted to cotton. Calcium arsenate was quoted on July 25th at 9 cents per pound, New York. Some sections now report that 10 per cent. of the total acreage may be dusted with calcium arsenate, but it is probable that the percentage for the cotton belt as a whole will be materially lower. The ineffectiveness of calcium arsenate in wet weather and the large measure of control exerted by heat and sunshine, whether or not calcium arsenate is applied, tend to retard the rapid extension of its use.

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PEACE AND PROGRESS OF AGRICULTURAL POPULATION.

The following has been received from the President of the International Institute of Agriculture, Rome :—

The seventh meeting of the General Assembly of the International Institute of Agriculture took place on May 25th last, when

on the motion of the French Government the following resolution was passed unanimously :—

"The General Assembly

being of opinion that farmers in all countries represent one of the elements that make for peace as between peoples; that order, tranquillty and continuity in daily work are the essential factors in agricultural prosperity and progress and thus the source of the well-being of Nations;

that the maintenance of the idea of peace is indispensable to the order and tranquillty of the peoples;

that farmers are among those who are most chiefly interested in the suppression of the dangers as well as of the horrors and disasters of war;

considering that the International Institute of Agriculture was founded, according to the generous sentiment of His Majesty Victor-Emmanuel III, King of Italy, in order that it might become a means of promoting solidarity among all farmers and thereby a powerful instrument of peace, resolves—

(1) to request the adhering States to establish among Agricultural Associations and Societies an active propaganda for the encouragement among farmers of the idea of agricultural progress which is indissolubly connected with peaceful development in international relations;

(2) to instruct the Permanent Committee to enter into communication with the various Governments in order, in agreement with them, to discover the best practical methods for influencing public opinion throughout the world, basing this propaganda on the necessity for the order, tranquillity and peace of the agricultural population in each country."

The General Assembly wishes emphatically to testify to the keen desire of the representatives of world agriculture, of whom the Institute is in the international sphere the chief representative organ, to see the agricultural classes in all countries take an active part in a pacific movement calculated to enhance the well-being and happiness of mankind, and to the pleasure with which they would welcome such action.

The General Assembly of the Institute considered that it could best express its sentiments by adopting as its own the generous resolution proposed by the French Delegation.

In communicating this resolution by the present letter I would ask you to be so good as to take steps to bring its purport to the notice of the agricultural classes in your country pending such action as the Permanent Committee may adopt with a view to giving it successful effect.

PERSONAL NOTES, APPOINTMENTS AND TRANSFERS, MEETINGS AND CONFERENCES, ETC.

Dr. F. J. F. Shaw, D.Sc., A.R.C.S., F.L.S., has been appointed to officiate as Imperial Economic Botanist from 25th August, 1924.

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Mr. P. V. Isaac, B.A., D.I.C., M.Sc., F.E.S., Second Entomologist (Dipterist), Pusa, has been granted leave on average pay for one month and 24 days from 30th October, 1924.

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Mr. T. F. Main, B.Sc., Offg. Director of Agriculture, Bombay, has been granted leave on average pay for six months and 24 days from date of relief by Dr. H. H. Mann.

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Sardar G. S. Cheema, M.Sc., Horticulturist to Government, Bombay, has been granted leave on average pay for seven months and 20 days from 1st April, 1925, Mr. H. P. Paranjpye officiating.

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Mr. Rudolph D. Anstead, M.A., Director of Agriculture, Madras, has been granted leave on average pay for eight months from 20th March, 1925.

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Mr. G. R. Hilson, B.Sc., Cotton Specialist, Madras, has been granted combined leave for eight months from the date of his relief as Offg. Secretary, Indian Central Cotton Committee.

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Mr. P. H. Rama Reddi, M.A., B.Sc., Deputy Director of Agriculture, III Circle, Madras, has been granted leave on average pay for six weeks, Mr. T. B. Nayudu officiating.

Dr. H. M. Leake, Sc.D., M.A., Director of Agriculture, United Provinces, has been granted combined leave for one year, three months and 30 days from 22nd August, 1924, in continuation of the leave already granted to him.

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Rai Sahib Pandit Nand Kishore Sharma, Divisional Superintendent of Agriculture, Bundelkhand Circle, has been appointed to officiate as Deputy Director of Agriculture, Central Circle, Cawnpore, *vice* Mr. T. R. Low granted leave for one month.

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Mr. R. L. Sethi, M.Sc., Economic Botanist to Government, United Provinces, was on leave on average pay for one month from 11th September, 1924, Mr. T. S. Sabnis, M.Sc., officiating.

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Mr. H. W. Stewart, Agricultural Engineer, Bihar and Orissa, was on leave on average pay for 12 days from 14th to 25th October, 1924.

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Sardar Darshan Singh, M.R.A.C., Deputy Director of Agriculture, II Circle, Punjab, was on leave on average pay for three months and 16 days from 15th June, 1924, Choudhury Mohammad Abdulla officiating.

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A Sporting College.

The College of Agriculture, Poona, is marked for its sporting spirit. A most striking proof of this was given by its successes in the recent Poona inter-collegiate sports. These sports are held annually in September and this (1924) is their fourth year. There are three Arts and Science Colleges, one Engineering College and one Law College in Poona, in addition to the College of Agriculture. Of these six, the College of Agriculture is the smallest, numbering 173 students against over 1,000 of the biggest, the Fergusson College. In spite of this, the College of Agriculture this year

carried off the Individual Championship and came second among the colleges for the College Championship. This almost equalled the college record in 1920, when the College of Agriculture carried off both Individual and College Championships. In the current year the College of Agriculture annexed in all twelve trophies, including both the first and second prizes in boxing, which was introduced for the first time. His Excellency the Right Hon'ble Sir Leslie Orme Wilson, P.C., G.C.I.E., C.M.G., D.S.O., in the course of his speech at the end of the gathering, said that, while the College of Agriculture might be small in numbers, it amply made up for that by the enthusiasm with which it supported its athletic representatives.

Review

Birds of an Indian Garden.—By T. Bainbrigge Fletcher, R.N., F.L.S., F.E.S., F.Z.S.; and C. M. Inglis, M.B.O.U., F.E.S., F.Z.S. In five parts with thirty coloured plates and numerous illustrations in the text. (Calcutta and Simla: Thacker, Spink & Co.) Price, Rs. 2 per part.

The series of papers dealing with some of the more common of our Indian birds, which has been appearing in this Journal for the last five years and which will close with this issue, has attracted considerable notice, and to meet the insistent demand for their republication in book form, Messrs. Thacker, Spink & Co. have been authorized to bring out this volume under a new title to avoid confusion with works of similar titles by other authors. In the original issue we were compelled to publish the articles without any regard to systematic order as the plates were completed. In re-issuing the series, however, the opportunity has been taken to re-arrange the papers, to amend the nomenclature in accordance with Mr. Stuart-Baker's Hand-list of Indian Birds, and also to add some black-and-white illustrations. This is the first book on Indian birds in which the commoner species have been so beautifully illustrated, and without doubt much of the popularity which these papers have attained during their appearance in this Journal has been due to the excellent series of plates printed from Mr. Inglis's original paintings. It is hoped that this publication will not only be helpful in enabling the non-ornithological reader to become acquainted with and take deep interest in bird-life, but will also provide the teachers in our secondary schools with a text for a branch of Nature study which is bound to appeal to their pupils.

The first part which has already been published contains plates and descriptions of the Jungle Crow, the House-Crow, the Jungle-Babbler, the Red-vented Bulbul and the Black Drongo or King Crow. It is proposed to bring out subsequent parts at short intervals.

NEW BOOKS

ON AGRICULTURE AND ALLIED SUBJECTS

1. Crops and Fruits, by J. R. Ainsworth-Davis. (The Resources of the Empire Series, Vol. I, Pt. 1.) Pp. 144. (London : Ernest Benn, Ltd.) Price, 21*s.* net.
2. Meat, Fish and Dairy Produce, by J. R. Ainsworth-Davis. (The Resources of the Empire Series, Vol. II.) Pp. 104. (London : Ernest Benn, Ltd.) Price, 21*s.* net.
3. Cotton in Australia : The possibilities and the limitations of Australia as a cotton-growing country ; containing numerous illustrations and graphs, together with data relating to the Australian Climate, Rainfall, Temperature, Soil Analyses and Cost of Production, by Richard Harding. Pp. xviii+270. (London : Longmans, Green & Co.) Price, 12*s.* 6*d.* net.
4. Rubber, Tea and Cacao, with special sections on Coffee, Spices and Tobacco, by W. A. Maclaren. (The Resources of the Empire Series, Vol. V.) Pp. 334. (London : Ernest Benn, Ltd.) Price, 21*s.* net.
5. Outlines of Fungi and Plant Diseases ; for students and practitioners of Agriculture and Horticulture, by F. T. Bennett. Pp. 266. (London : Macmillan & Co.) Price, 7*s.* 6*d.*
6. Plant Alkaloids, by T. A. Henry. Second edition. Pp. viii+456+8 plates. (London : J. & A. Churchill.) Price, 28*s.* net.
7. The Determination of Hydrogen Ions, by W. Mansfield Clark. Second edition. Pp. 480+42 figs. (Baltimore : Williams and Wilkins Co.) Price, $5·50.

THE following publications have been issued by the Imperial Department of Agriculture in India since our last issue :—

Memoirs.

1. The Mahali Disease of Coconuts in Malabar, by S. Sundararaman, M.A.; and T. S. Ramakrishnan, B.A. (Botanical Series, Vol. XIII, No. 4.) Price, As. 12 or 1*s*.

2. Some Digestibility Trials on Indian Feeding Stuffs, by P. E. Lander, M.A., D.Sc., A.I.C.; and Pandit Lal Chand Dharmani, L.AG. (Chemical Series, Vol. VII, No. 4.) Price, As. 12 or 1*s*.

3. Papers on Indian Tabanidæ, by P. V. Isaac, B.A., D.I.C., M.Sc., F.E.S.; Two Drosophilidæ from Coimbatore and A New Aphidiphagous Fly, by J. R. Malloch; Notes on Indian Odonata in the Pusa Collection, by Major F. C. Fraser, I.M.S.; On New and Old Oriental Cicindelidæ, by Dr. Walther Horn. (Entomological Series, Vol. VIII, Nos. 5–9.) Price, R. 1-4 or 2*s*.

Bulletin.

4. Tamarind as a Source of Alcohol and Tartaric Acid, by H. N. Batham, M.A.; and L. S. Nigam, L.AG. (Pusa Bulletin No. 153.) Price, As. 3 or 4*d*.

Miscellaneous.

5. Catalogue of Indian Insects. Pt. 4—Trypetidæ (Trypaneidæ), by R. Senior-White, F.E.S., F.R.S.T.M.&H. Price, As. 8 or 9*d*.

LIST OF AGRICULTURAL PUBLICATIONS IN INDIA FROM THE 1ST FEBRUARY TO THE 31ST JULY, 1924

No.	Title	Author	Where published
	GENERAL AGRICULTURE		
1	The *Agricultural Journal of India*, Vol. XIX, Parts II, III and IV. Price, R. 1-8 or 2*s.* per part. Annual subscription, Rs. 6 or 9*s.* 6*d.*	Edited by the Agricultural Adviser to the Government of India.	Messrs. Thacker, Spink & Co., Calcutta.
2	Proceedings of the Board of Agriculture in India held at Bangalore on the 21st January, 1924, and following days, with Appendices. Price, R. 1.	Issued by the Agricultural Adviser to the Government of India.	Government Printing, India, Calcutta.
3	Proceedings of the Cattle Conference held at Bangalore on 22nd and 23rd January, 1924, with Appendices. Price, As. 9.	Ditto	Ditto
4	Annual Report of the Board of Scientific Advice for India for 1922-23. Price, R. 1.	Issued by the Board of Scientific Advice for India.	Ditto
5	Agricultural Statistics of India, 1921-22, Vol. I. Price, R. 1-2.	Issued by the Commercial Intelligence Department of India.	Ditto
6	Estimates of Area and Yield of Principal Crops in India, 1922-23. Price, As. 12.	Ditto	Ditto
7	Quinquennial Report on the Average Yield per Acre of Principal Crops in India for the period ending 1921-22. Price, As. 8.	Ditto	Ditto
8	Poultry Farming in the East. Price, Rs. 4.	Mrs. A. K. Fawkes, Poultry Expert to the Government of United Provinces.	Pioneer Press, Allahabad.
9	Improvement of Paddy Crop with special reference to West Coast Madras Department of Agriculture Leaflet No. 36 (English and Malayalam).	K. Unnikrishna Menon.	Government Press, Madras.
10	Cotton Suitable for Cultivation in the Dry Lands of Kurnool District. Madras Department of Agriculture Leaflet No. 37 (Telugu).	P. H. Rama Reddi, M.A., B.Sc., Deputy Director of Agriculture, III Circle, Madras.	Ditto

LIST OF AGRICULTURAL PUBLICATIONS—*contd.*

No.	Title	Author	Where published
	General Agriculture—contd.		
11	Villagers' Calendar, 1924-25 (English, Tamil, Telugu, Malayalam and Kanarese).	Issued by the Department of Agriculture, Madras.	Government Press, Madras.
12	Year Book of the Agricultural Department in Sind. Bombay Department of Agriculture Bulletin No. 113. Price, As. 8-6.	Issued by the Department of Agriculture, Bombay.	Government Central Press, Bombay.
13	Studies on the Rice Plant and on Rice Cultivation. Bombay Department of Agriculture Bulletin No. 114. Price, As. 13.	K. V. Joshi, B.Ag., Rice Specialist, and M. V. Gadkari, B.Ag., Assistant to the Rice Specialist, Bombay.	Ditto
14	Shevri as a Fodder Crop. Bombay Department of Agriculture Bulletin No. 115. Price, As. 3.	Issued by the Department of Agriculture, Bombay.	Yeravda Prison Press, Poona.
15	Triennial Report of the Jacobabad Experimental Station for the years 1919-20, 1920-21 and 1921-22. Price, As. 6.	T. F. Main, B.Sc., Deputy Director of Agriculture, Sind.	Government Central Press, Bombay.
16	Annual Report of the Department of Agriculture, Bombay Presidency, for the year 1922-23. Price, R. 1.	Issued by the Department of Agriculture, Bombay.	Ditto
17	The Economic Progress Report of the Rural Areas of the Bombay Presidency, 1911–1922. (For official use only.)	Dr. Harold H. Mann, D.Sc., Director of Agriculture, Bombay, Poona.	Ditto
18	The Reaping of Broadcast Highland Aus Paddy. Bengal Department of Agriculture Leaflet No. 1 of 1924 (English and Bengali).	R. S. Finlow, B.Sc., Director of Agriculture, Bengal.	Bengal Government Press, Calcutta.
19	On the Improvement of Cattle and Economic Welfare. Bengal Department of Agriculture Leaflet (Bengali).	Issued by the Department of Agriculture, Bengal.	Ditto
20	Some Paddies experimented upon and found suitable for the East Bengal Soil. Bengal Department of Agriculture Leaflet No. 3 of 1924 (Bengali).	Ditto	Ditto
21	Water Hyacinth, a Manure for Jute. Bengal Department of Agriculture Leaflet No. 4 of 1924.	R. S. Finlow, B.Sc., Director of Agriculture, Bengal.	Ditto

LIST OF AGRICULTURAL PUBLICATIONS—*contd.*

No.	Title	Author	Where published
	General Agriculture—contd.		
22	A Systematic History of the Jute Experiments in Bengal. Bengal Department of Agriculture Bulletin No. 2 of 1921.	R. S. Finlow, B.Sc., Director of Agriculture, Bengal.	Bengal Government Press, Calcutta.
23	Report on the Demonstration Work carried out in the Southern Circle, Central Provinces, for 1922-23. Price, As. 8.	J. C. McDougall, M.A., B.Sc., Offg. Deputy Director of Agriculture, Southern Circle, Nagpur.	Government Press, Central Provinces, Nagpur.
24	Reports on the Agricultural Stations in the Southern Circle, Central Provinces, for 1922-23. Price, R. 1.	Ditto	Ditto
25	Report on the Demonstration Work carried out in the Eastern Circle, Central Provinces, for 1922-23. Price, As. 8.	J. C. McDougall, M.A., B.Sc., Offg. Deputy Director of Agriculture, Eastern Circle, Raipur.	Ditto
26	Reports on the Agricultural Stations in the Eastern Circle, Central Provinces, for 1922-23. Price, R. 1-8.	Ditto	Ditto
27	Reports on the Agricultural Stations in the Western Circle, Central Provinces, for 1922-23. Price, As. 8.	S. G. Mutkekar, B.Ag., M.Sc., Offg. Deputy Director of Agriculture, Western Circle, Amraoti.	Ditto
28	Reports on the Agricultural Stations in the Northern Circle, Central Provinces, for 1922-23. Price, Rs. 2.	J. H. Ritchie, M.A., B.Sc., Deputy Director of Agriculture, Northern Circle, Jubbulpore.	Ditto
29	Report on the Experimental Farm attached to the Agricultural College, Nagpur, Central Provinces, for 1922-23. Price, As. 8.	R. G. Allan, M.A., Principal, Agricultural College, Nagpur.	Ditto
30	Season and Crop Report, Bihar and Orissa, for 1923-24.	Issued by the Department of Agriculture, Bihar and Orissa.	Government Press, Gulzarbagh.
31	Agricultural Statistics of Bihar and Orissa for 1922-23.	Ditto	Ditto
32	Annual Report of the Department of Agriculture, Bihar and Orissa, for the year ending the 31st March, 1924.	Ditto	Ditto

LIST OF AGRICULTURAL PUBLICATIONS—*contd.*

No.	Title	Author	Where published
		General Agriculture—contd.	
33	Pusa Pedigree Herd in North Bihar. Bihar and Orissa Department of Agriculture Bulletin.	Issued by the Department of Agriculture, Bihar and Orissa.	Government Press, Gulzarbagh.
34	Silage	C. H. Parr, B.Sc., Deputy Director in charge of Cattle Breeding Operations, United Provinces.	Government Press, United Provinces, Allahabad.
35	Notes on Upper India Hedges.	A. E. P. Griessen, Deputy Director of Gardens, United Provinces.	Ditto
36	Notices regarding Cotton Seed White-flowered (Neglectum Bhatla). Punjab Department of Agriculture Leaflet (Urdu).	Issued by the Department of Agriculture, Punjab.	Government Printing, Punjab, Lahore.
37	Improved *Gur* Boiling Furnaces. Punjab Department of Agriculture Leaflet No. 24.	Malik Sultan Ali, I.A.S., Deputy Director of Agriculture, Gurdaspur.	Ditto
38	Groundnut and Its Cultivation. Punjab Department of Agriculture Leaflet No. 13 (revised).	Issued by the Department of Agriculture, Punjab.	Ditto
39	Notices on "Cotton Seed" for the knowledge of Zemindars of Lower Bari Doab Colony. Punjab Department of Agriculture Leaflet.	Ditto	Ditto
40	Difference between 4F and 285F Punjab American Cotton. Punjab Department of Agriculture Leaflet No. 28.	Ditto	Ditto
41	Shelter Hedges round Cotton Fields. Punjab Department of Agriculture Leaflet No. 29.	Ditto	Ditto
42	Report on the Operations of the Department of Agriculture, Punjab, for the year ending 30th June, 1923. Price, Rs. 2 or 2*s*. 8*d*.	Ditto	Ditto
43	Prospectus of the Punjab Agricultural College.	Ditto	Ditto
44	Seasonal Notes of the Punjab Department of Agriculture for May 1924. Price, As. 3.	Ditto	Government Printing, Punjab, and Mufid-i-am Press, Lahore.

LIST OF AGRICULTURAL PUBLICATIONS—*contd.*

No.	Title	Author	Where published
	General Agriculture—contd		
45	Annual Report on the Operations of the Department of Agriculture, Burma, for the year ended 30th June, 1923.	Issued by the Department of Agriculture, Burma.	Government Printing, Burma, Rangoon.
46	Annual Reports of Agricultural Stations, Burma, for the year ended 30th June, 1923:—(1) Mandalay, (2) Hmawbi, (3) Mahlaing, (4) Tatkon, (5) Akyab, (6) Hopin, (7) Pwinbyu, (8) Padu, (9) Yawnghwe, and (10) Allanmyo; and Annual Reports of the Agricultural Engineer, Agricultural Chemist, Entomologist, Economic Botanist and Superintendent, Stock-Breeding, for the year ended 30th June, 1923.	Ditto	Ditto
47	Leguminous Crops Cultivated for their Roots. Burma Department of Agriculture Leaflet No. 10.	Ditto	Ditto
48	The Cultivation of Coconut in Arakan. Burma Department of Agriculture Leaflet No. 15.	Ditto	Ditto
49	The Commoner Grasses in Burma. Burma Department of Agriculture Bulletin No. 20.	Ditto	Ditto
50	Notes on Tour in the Coconut Planting Districts of Madras Presidency. Burma Department of Agriculture Bulletin No. 22.	Ditto	Ditto
51	Agricultural Calendar for 1923-24 (in Burmese).	Ditto	Ditto
52	Preservation of Cowdung. Assam Department of Agriculture Leaflet (Assamese).	Issued by the Department of Agriculture, Assam.	Assam Secretariat Printing Office, Shillong.
53	Proper Methods of covering Cows. Assam Department of Agriculture Leaflet (Assamese).	Ditto	Ditto
54	The *Bengal Agricultural Journal* (Quarterly), (in English and Bengali). Annual subscription, R. 1-4; single copy, As. 5.	Issued by the Department of Agriculture, Bengal.	Sreenath Press, Dacca.

LIST OF AGRICULTURAL PUBLICATIONS—*contd.*

No.	Title	Author	Where published
	General Agriculture—concld.		
55	The *Journal of the Madras Agricultural Students' Union* (Monthly). Annual subscription, Rs. 4.	Madras Agricultural Students' Union.	The Electric Printing Works, Coimbatore.
56	*Quarterly Journal of the Indian Tea Association.* Price, As. 6 per copy.	Scientific Department of the Indian Tea Association, Calcutta.	Catholic Orphan Press, Calcutta.
57	*Poona Agricultural College Magazine* (Quarterly). Annual subscription, Rs. 2.	College Magazine Committee, Poona.	Arya Bhusan Press, Poona.
58	*Journal of the Mysore Agricultural and Experimental Union* (Quarterly). Annual subscription, Rs. 3.	Mysore Agricultural Experimental Union.	Bangalore Press, Bangalore.
59	*Indian Scientific Agriculturist* (Monthly). Annual subscription, Rs. 4.	H. C. Sturgess, Editor; J. W. McKay, A.R.C.SC., N.D.A., Consulting Editor.	Calcutta Chromotype Company, 52-53, Bow Bazar Street, Calcutta.
60	The *Planters' Chronicle* (Weekly).	United Planters' Association of South India, Coimbatore.	E. P. Works, Coimbatore.
61	*Rural Bengal* (Monthly) ..	N. N. Gupta, B.A., Ph.D., B.Sc., Editor.	Russa Art Press, Bhawanipur, Calcutta.
62	*Krishak* (Bengali) (Monthly). Price, As. 5 per copy; Annual subscription, Rs. 3-3.	U. C. Bannerji, Editor.	Sri Ram Press, 162, Bow Bazar Street, Calcutta.
63	*The Old Boys Magazine, Agricultural College, Cawnpore,* (Quarterly). Price, per copy As. 8; Annual subscription, Rs. 2.	M. L. Saksena, L.Ag., Editor.	Cawnpore Printing Press.
	BOTANY		
64	Studies in Indian Tobaccos. No. 4—Parthenocarpy and Parthenogenesis in the varieties of *Nicotiana Tabacum* L. var. *Cuba* and var. *Mirodata.* No. 5—The Inheritance of Characters in *Nicotiana rustica.* Memoirs of the Department of Agriculture in India, Botanical Series, Vol. XIII, No. 1. Price, Rs. 2 or 2*s.* 9*d.*	Gabrielle L. C. Howard, M.A., Second Imperial Economic Botanist, Pusa.	Messrs. Thacker, Spink and Co., Calcutta.
65	Practical Botany for Indian Students.	Diwan Bahadur K. Rangachariar, M.A., L.T.	Government Press, Madras.

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No.	Title	Author	Where published
	MYCOLOGY		
66	The Wilt Disease of Safflower. Memoirs of the Department of Agriculture in India, Botanical Series, Vol. XIII, No. 2. Price, R. 1 or 1*s.* 6*d.*	S. D. Joshi, B.SC., Research Assistant, Plant Pathological Section, Department of Agriculture, United Provinces.	Messrs. Thacker, Spink and Co., Calcutta.
67	Jowar Smut. Burma Department of Agriculture Cultivators' Leaflet No. 37.	Issued by the Department of Agriculture, Burma.	Government Printing, Burma, Rangoon.
68	Earcockle. Punjab Department of Agriculture Bulletin (in Urdu and Gurmukhi). (Reprinted.)	Issued by the Department of Agriculture, Punjab.	Government Printing, Punjab, Lahore.
69	Mahali. Madras Department of Agriculture Leaflet No. 35 (in Malayalam).	M. Govind Kidavu, Deputy Director of Agriculture, VII Circle, Madras.	Government Press, Madras.
	AGRICULTURAL BACTERIOLOGY		
70	Some Studies in Bio-chemistry.	Some students of Dr. Gilbert Fowler, D.SC.	The Phœnix Printing House, Bangalore.
	ENTOMOLOGY		
71	Report of the Proceedings of the Fifth Entomological Meeting, held at Pusa from 5th to 10th February, 1923. Price, Rs. 9-8.	Edited by T. Bainbrigge Fletcher, R.N., F.L.S., F.E.S., F.Z.S., Imperial Entomologist, Pusa.	Government Printing, India, Calcutta.
72	Bee-keeping. Pusa Agricultural Research Institute Bulletin No. 46. (Second Edition.) Price, Rs. 2.	C. C. Ghosh, B.A., Assistant to the Imperial Entomologist.	Ditto
73	The External Morphology and Bionomics of the commonest Indian Tick (*Hyalomma ægyptium*). Pusa Agricultural Research Institute Bulletin No. 152. Price, R. 1.	Mohammad Sharif, M.A., F.R.M.S.	Ditto
74	Butterflies of India. Price, Rs. 30.	Chas. B. Antram, F.E.S.	Messrs. Thacker, Spink and Co., Calcutta.
75	Lac Cultivation. Bengal Department of Agriculture Bulletin No. 1 of 1924 (English and Bengali).	Issued by the Department of Agriculture, Bengal.	Bengal Government Press, Calcutta.

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No.	Title	Author	Where published
	Entomology—concld.		
76	Cotton Insects. Punjab Department of Agriculture Leaflet Nos. 25, 26 and 27.	M. Afzal Hussain, M.Sc., M.A., Entomologist to Government of Punjab, Lyallpur.	Government Printing, Punjab, Lahore.
77	Rats damaging Paddy. Burma Department of Agriculture Leaflet No. 36.	Issued by the Department of Agriculture, Burma.	Government Printing, Burma, Rangoon.
	VETERINARY		
78	Proceedings of the Second Meeting of Veterinary Officers in India, held at Calcutta from 26th February to 2nd March, 1923 (with Appendices). Price, R. 1-12.	Issued by the Agricultural Adviser to the Government of India.	Government Printing, India, Calcutta.
79	Black Quarter. Madras Civil Veterinary Department Leaflet No. 7.	D. A. D. Aitchison, M.R.C.V.S., Ag. Chief Superintendent, Civil Veterinary Department, Madras.	Government Press, Madras.
80	Recurrent Orchitis in Donkey Colts at Government Cattle Farm, Hissar. Punjab Veterinary Bulletin No. 4. (Reprinted.)	R. Branford, M.R.C.V.S., Superintendent, Government Cattle Farm, Hissar.	Government Printing, Punjab, Lahore.
81	Surra Transmission Experiments with *Tabanus albimedius* and Ticks. Punjab Veterinary Bulletin No. 12. (Reprinted.)	Captain H. E. Cross, M.R.C.V.S., Camel Specialist, Sohawa.	Ditto
82	Prospectus of the Punjab Veterinary College, Lahore.	Issued by the Department of Agriculture, Punjab.	Ditto
83	Syllabus of Lectures at Punjab Veterinary College.	Ditto	Ditto
84	Fly Survey Report, Punjab ..	Captain H. E. Cross, M.R.C.V.S., Camel Specialist, Sohawa.	Ditto